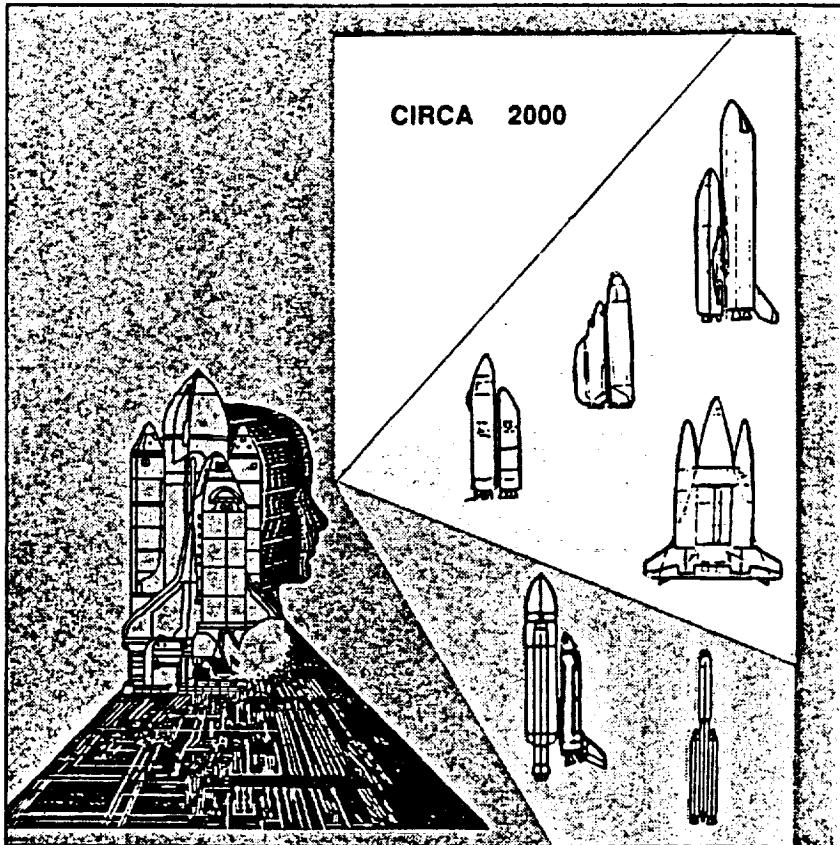


Shuttle Ground Operations Efficiencies/Technologies Study

BOEING

AEROSPACE OPERATIONS



FINAL REPORT PHASE 2
Volume 2 of 6

FINAL PRESENTATION MATERIAL

W. J. Dickinson
KSC Study Manager
(407) 867-2780

KENNEDY SPACE CENTER
NAS10-11344
May 5, 1988

A. L. Scholz
Boeing Study Manager
(407) 867-2334



**SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES
STUDY
PHASE 2 FINAL REPORT**

STUDY REPORT

- | | |
|----------|--|
| Volume 1 | Executive Summary |
| Volume 2 | Final Presentation Material |
| Volume 3 | Space-vehicle Operational Cost-drivers Handbook (SOCH)
Part 1 Cost Driver Checklists
Part 2 SOCH Reference Information |
| Volume 4 | Simplified Launch System Operational Criteria (SLSOC) |
| Volume 5 | Technology References |
| Volume 6 | Circa 2000 System |

Volume 1 EXECUTIVE SUMMARY

The Executive Summary provides an overview of major elements of the Study. It summarizes the Study analytic efforts, the documentation developed, and reviews the recommendations resulting from the analyses conducted during Phase 2 of the Study.

Volume 2 PHASE 2 FINAL ORAL PRESENTATION

The Final Presentation Material volume contains the charts used in the Final Oral Presentations for Phase 2, at KSC on April 6, 1988. A brief, overall review of the Study accomplishments is provided. An indepth review of the documentation developed during the last quarter of Phase 2 of the Study is presented. How that information was used in this Study is explained in greater detail in Vols. 3 and 4. An initial look at the topics planned for the upcoming Workshops for Government/Industry is presented along with a cursory look at the results expected from those Workshops.

Volume 3 SPACE-VEHICLE OPERATIONAL COST DRIVERS HANDBOOK (SOCH)

The Space-vehicle Operational Cost drivers Handbook (SOCH) was assembled early in Phase 2 of the Study as one of the fundamental tools to be used during the rest of the Phase. The document is made up of two parts -- packaged separately because of their size.

Part 1 Presents, in checklist format, the lessons learned from STS and other programs. The checklist items were compiled so that the information would be easily usable for a number of different analytical objectives, and then grouped by disciplines or gross organizational, and/or functional responsibilities. Content of the checklists range from 27 management; 11 system engineering; 8 technology; and 19 design topics -- with a total of 793 individual checklist items. Use of this Handbook to identify and reduce Cost Drivers is recommended for designers, Project and Program managers, HQ Staff, and Congressional Staffs.

Part 2 Contains a compilation of related reference information about a wide variety of subjects including ULCE, Deming, Design/Build Team concepts as well as current and previous space launch vehicle programs. Information has been accumulated from programs that range from, Saturn/Apollo, Delta, Titan, and STS to NASP and Energia.

Volume 4 SIMPLIFIED LAUNCH SYSTEM OPERATIONAL CRITERIA (SLSOC)

The SLSOC document was developed from the generic Circa 2000 System document, Vol. 6; is similar in content; and also indicates the manpower effect of the elimination of many STS-type cost drivers. The primary difference between the two documents is the elimination of all generic Circa 2000 requirements (and support) for manned-flight considerations for the ALS vehicle. The data content of the two documents, while similar in nature, was reorganized and renumbered for SLSOC so that it could be used as the basis for various panels and subpanels in an ALS Workshop.

PHASE 2 STUDY REPORT (Cont'd)

Historical data is the basis for the conclusion that incremental improvements of technology and methods cannot significantly improve LCC (by an order-of-magnitude) without major surgery. A system enabling the development of a radically simplified operational concept, reflected in SLSOC, was included so that proposed designs (and operations) could be compared to systems providing for simplicity -- rather than the current STS complexity.

The identified operational cost drivers from STS plus other historical data were used as background reference information in the development of each example concept designed to eliminate cost drivers. These example concepts, when integrated, would support an order-of-magnitude cost reduction in current (STS), exorbitant Life Cycle Costs (LCC). Individual operational requisites were developed for each element in the associated management systems, integration engineering, vehicle systems, and supporting facilities. These have associated rationale, sample concepts, identification of technology developments needed, and technology references to abstracts. The technology abstracts are provided in a separate volume, Vol. 5.

Technology changes almost daily, thus past trade studies may no longer be valid. In addition, old "trades" often used inaccurate estimates of "real" operational costs. Vehicle designs are compromises and have been performance oriented with operations methods/techniques based on those designs. It is the intent of our example concepts in the SLSOC to stimulate design teams to improve or replace conventional design approaches. Obviously, it is up to the responsible program design teams to provide design solutions to resolve operational cost drivers.

Volume 5 TECHNOLOGY REFERENCES

This document provides a repository for the Technology References for the SLSOC and the CIRCA 2000 System documents. The technology references, mostly from NASA RECON, are supplied to the reader to facilitate analysis on either the SLSOC or the CIRCA 2000 System documents. Some data references were also obtained via DIALOG. If more technical information is desired by an analyst, he must obtain the additional documentation thru his library or from some other appropriate source. The XTKB (EXPANDED TECHNOLOGY KNOWLEDGE BASE) provided a user-friendly tool for our analyses in identifying and obtaining the computerized database reference information contained in this document. Thousands of abstracts were screened to obtain the 300 plus citations pertinent to SLSOC in this Volume.

Volume 6 CIRCA 2000 SYSTEM OPERATIONAL REQUIREMENTS

The Circa 2000 System Operations Requirements were developed using STS as a working data source. We identified generic operations cost drivers resulting from performance-oriented vehicle design compromises and the operations methods/techniques based on those designs. Those Cost Drivers include high-cost, hazardous, time & manpower-consuming problem areas involving vehicles, facilities, test & checkout, and management / system engineering. Operational requisites containing rationales, example concepts, identification of technology developments needed, and identification of technology references using available abstracts were developed for each Cost Driver identified. Elimination of cost drivers significantly reduces recurring costs for prelaunch processing and launch operations of space vehicles.

NOTE: Volumes 1,3,4 and 5 are being widely distributed. Volume 2 is a copy of presentation material already distributed and Volume 6 will be distributed only on request. Copies of the full report will be placed in libraries at NASA HQ., JSC, KSC, MSFC and NASA RECON. Individual volume copies may be obtained by forwarding a request to W. J. Dickinson, KSC PT-FPO, (407) 867-2780.

- INTRODUCTION**
- OPERATIONAL ANALYSES**
- MANAGEMENT & SYSTEM ENGINEERING**
- AVIONICS & SOFTWARE**
- POWER**
- STRUCTURES & MATERIALS**
- PROPELLION**
- FACILITIES & SUPPORT EQUIPMENT**
- CONCLUSIONS & PRODUCT SUMMARY**
- PHASE 3**

NO FACING PAGE TEXT

SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES STUDY
PHASE - 2 FINAL PRESENTATION

PRESENTED AT
KSC
APR. 6, 1988

INTRODUCTION

OPERATIONAL ANALYSES

MANAGEMENT & SYSTEM ENGINEERING

AVIONICS & SOFTWARE

POWER

STRUCTURES & MATERIALS

PROPELLION

FACILITIES & SUPPORT EQUIPMENT

CONCLUSIONS & PRODUCT SUMMARY

PHASE 3

STUDY OBJECTIVES

PRESENTED AT
KSC
APR. 6, 1988

PHASE 1 (Completed 5/4/87)

Using the STS system as a working model and certified data source, identified existing or new technologies and changes to flight hardware or processing methodologies to reduce vehicle processing time, program manpower (and costs).

A decision was made to concentrate on orbiter, vehicle integration, and launch processing activities for this phase of the study. Identified technology items that would reduce operations costs but did not find any item that would significantly change the life cycle costs of the current program (down time and modification costs considered).

PHASE 2
(Complete 5/4/88)

Analyze and apply cost drivers, defined in Phase 1, to the ALS Program Requirements. Develop and document Simplified Launch System Operations Criteria (SLSOC) based on these cost drivers.

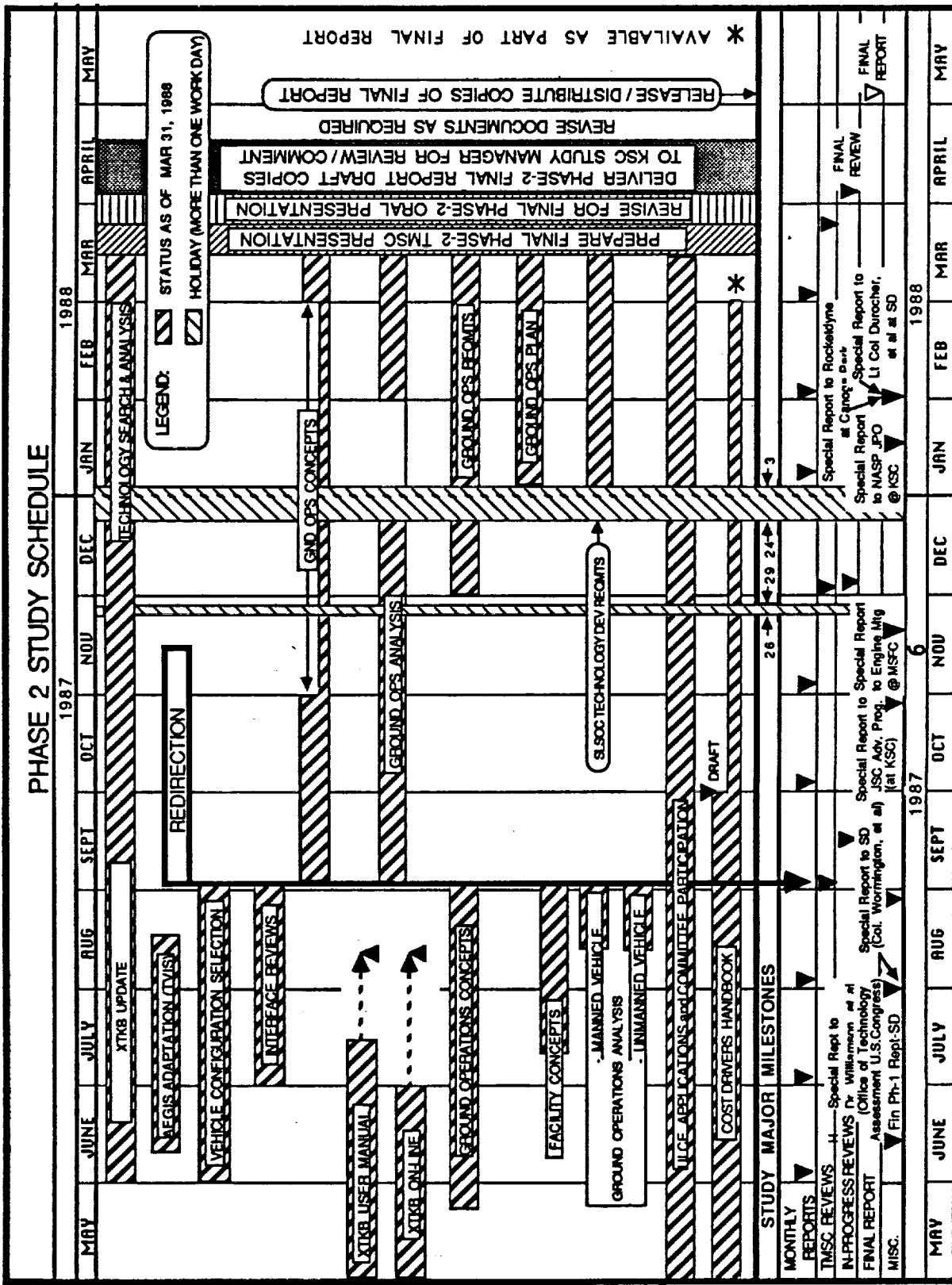
PHASE 3
(Scheduled Completion May 89)

Develop and conduct operations cost driver workshops for down-selected, prime ALS contractors; document results of these workshop discussions; review preliminary program designs from operations cost driver aspect and document results.

SGOET STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SGOET STUDY
PHASE 2 SCHEDULE

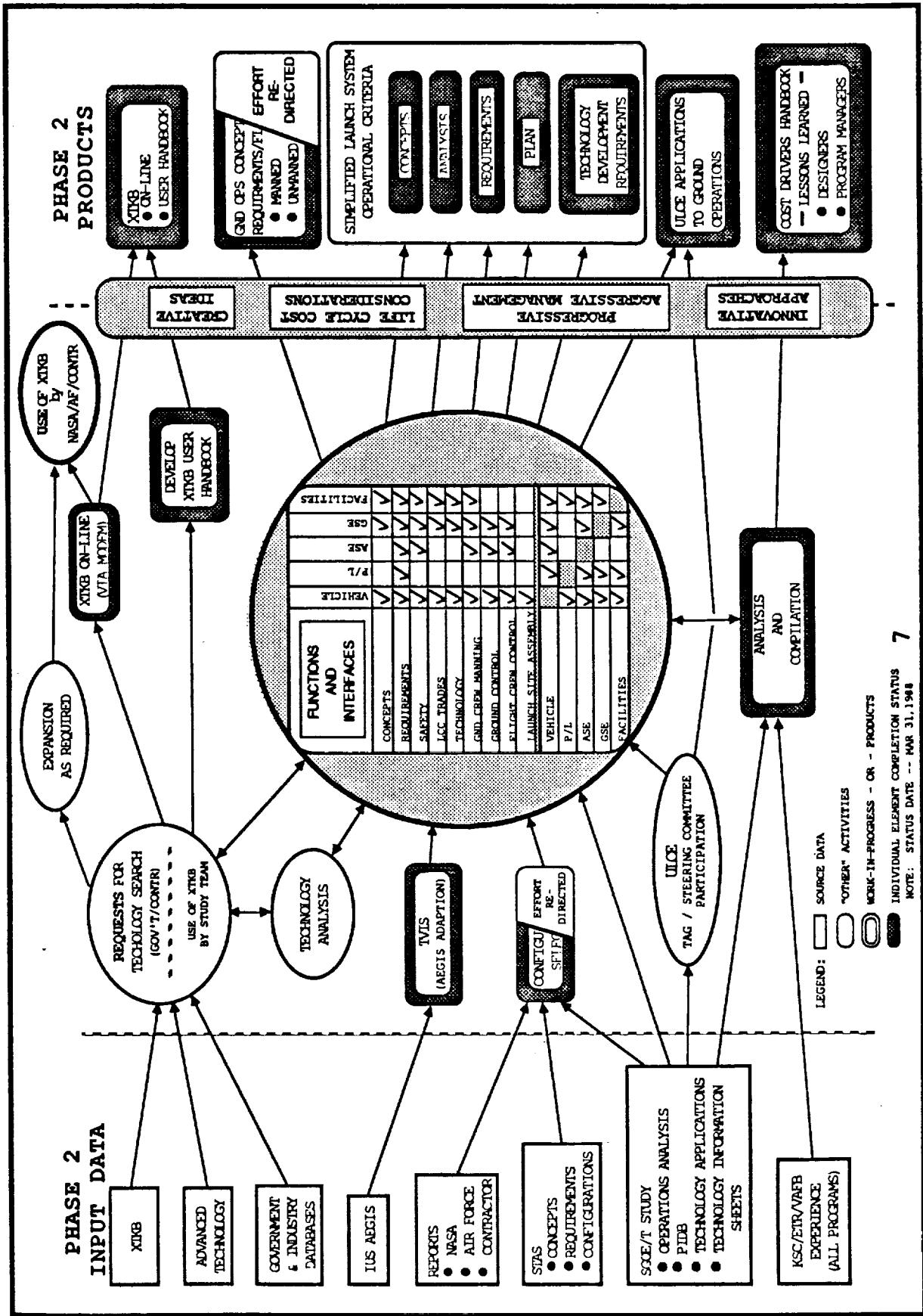
PRESENTED AT
KSC
APR. 6, 1988



**SGO E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING**

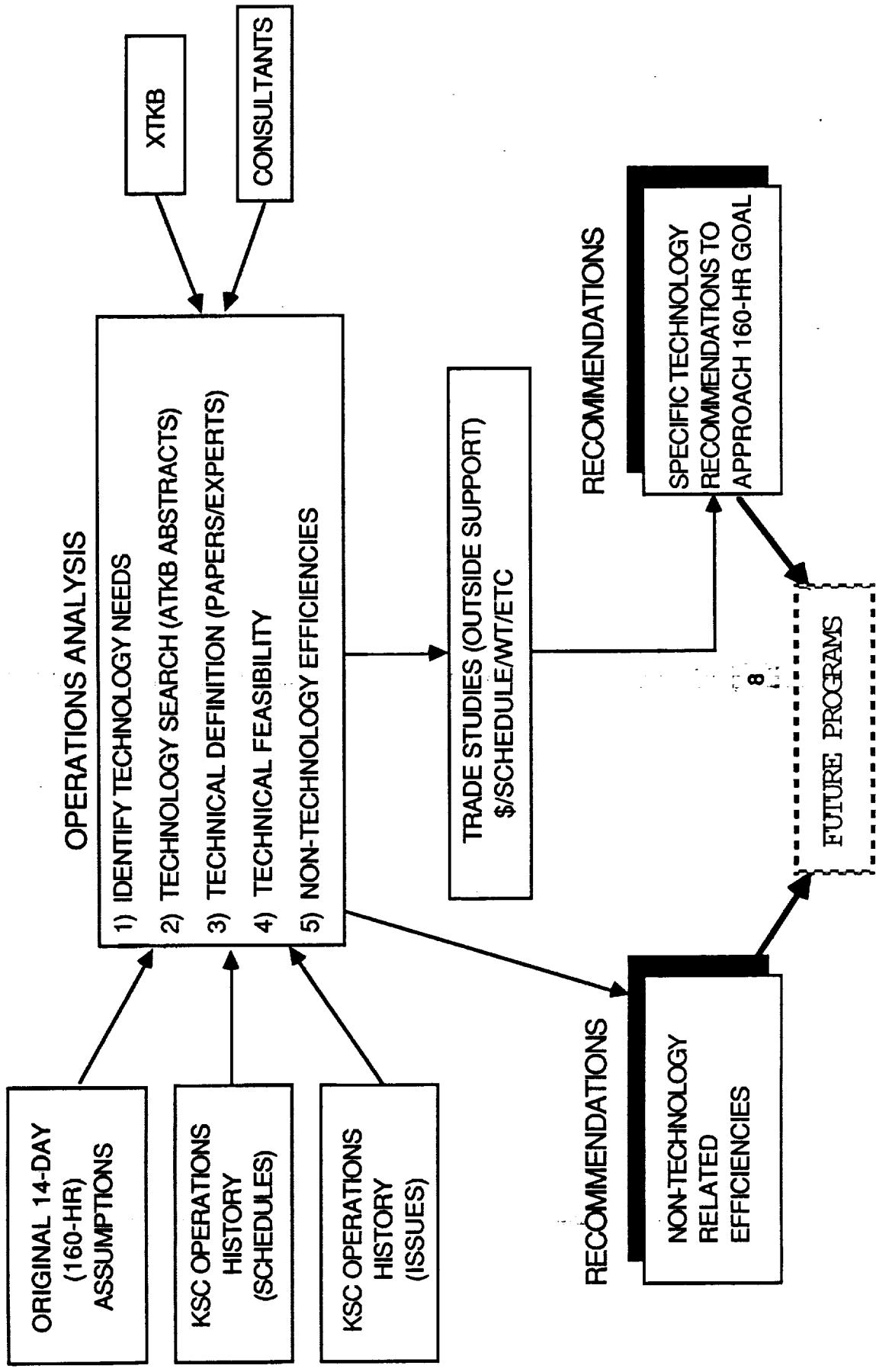
**SGOE/T STUDY
PHASE 2 FLOW**

PRESENTED AT
KSC
APR. 6, 1988



OPERATIONS ANALYSIS FLOW

PRESENTED AT
KSC
APR. 6, 1988



ANALYSIS SUPPORT
(Phase 1)

PRESENTED AT
KSC
APR. 6, 1988

OTHER COMPUTER DATABASES

PRACA

107,818 RECORDS

RECON

2.4×10^6 RECORDS

COMMERCIAL

OMRSD
RECORDS

RECORDS

STUDY COMPUTER DATABASES

REFERENCE FILE SYSTEM

243 RECORDS

PRELIMINARY ISSUES CATALOG

3,260 RECORDS

TECHNOLOGY IDENTIFICATION SHEETS (TIS)

143 RECORDS

XTKB

22,750 RECORDS

PRACA EXTRACT

RECORDS

160 - HOUR ASSUMPTIONS

572 RECORDS

ANALYSIS SUPPORT

HARDCOPY DATA

ISSUE SOURCE DOCUMENTS

OMI's

MHMP/COST DATA

KSC HISTORICAL SCHEDULES

KSC LIBRARY FICHE HARDCOPY INTER-LIBRARY

LEGEND:

ELECTRONIC
KEYBOARD
ENTRY

HARDCOPY
-
-
-
-

9
ELECTRONIC
-
-
-
-

TRANSFER

QUERY

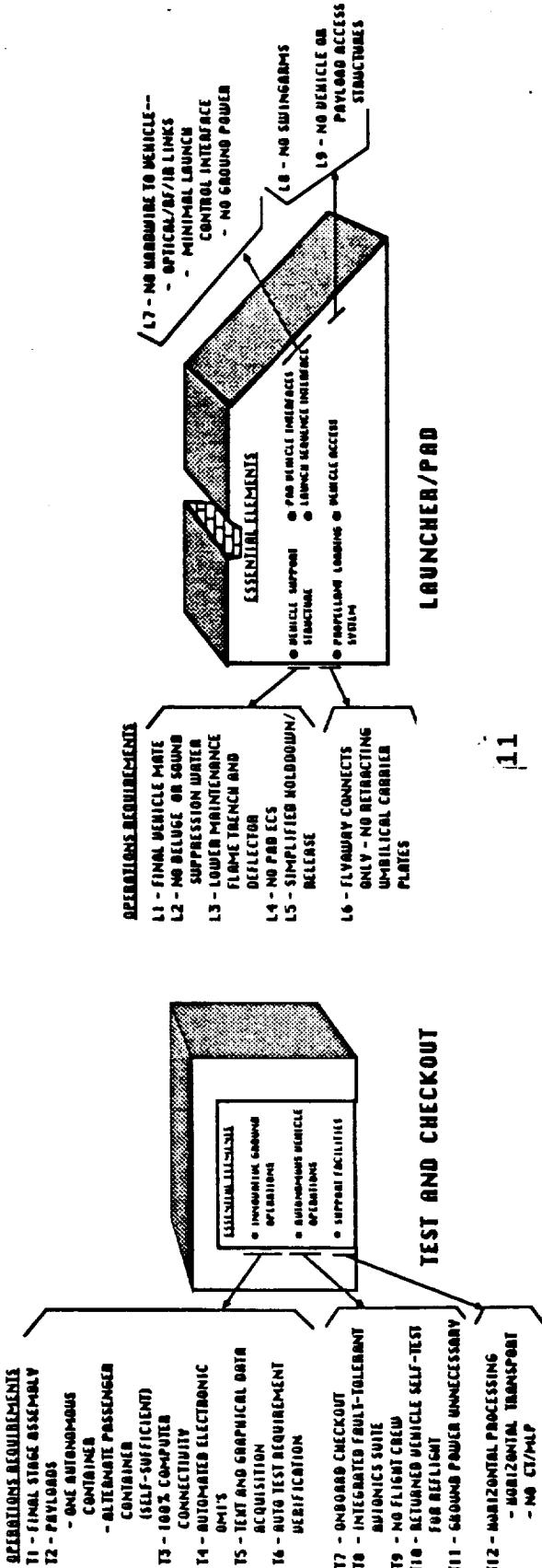
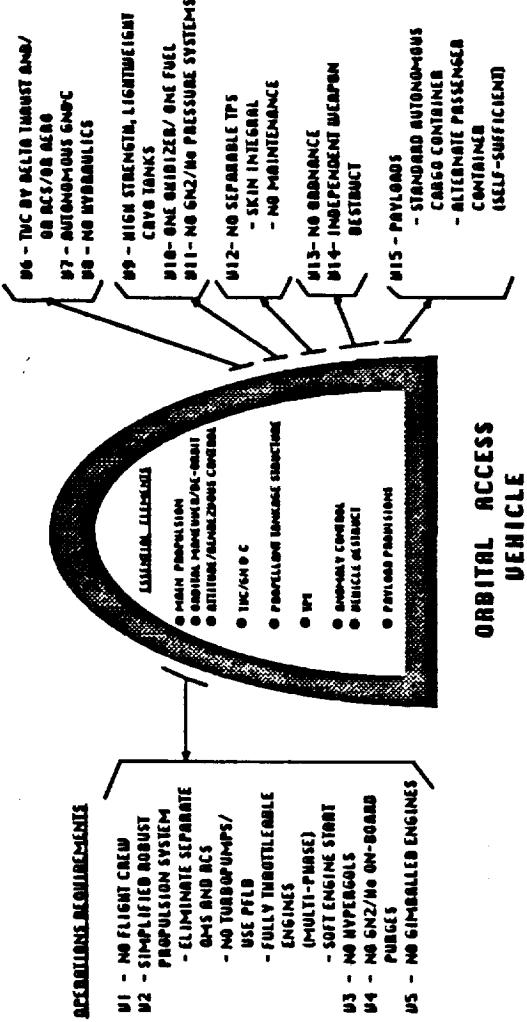
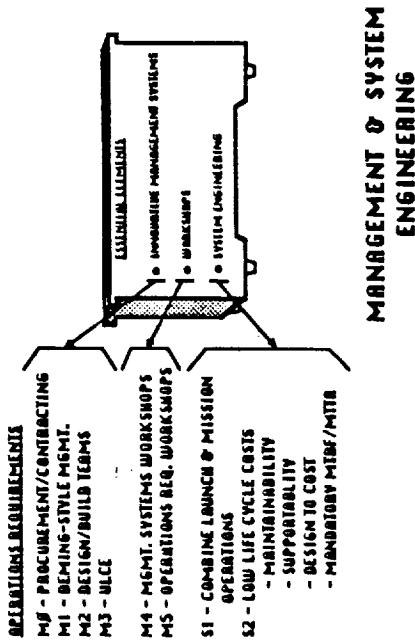
CIRCA 2000 SYSTEM INTRODUCTION

- OBJECTIVE -- IDENTIFY OPERATIONS COST DRIVERS THAT, IF CORRECTED, WILL SIGNIFICANTLY REDUCE OVERALL LIFE CYCLE COSTS.
- APPROACH -- DEVELOP INDIVIDUAL OPERATIONAL REQUISITES FOR:
 - ORBITAL ACCESS VEHICLE
 - TEST & CHECKOUT TECHNIQUES
 - SUPPORTING FACILITIES
 - ASSOCIATED MANAGEMENT & SYSTEM ENGINEERING
- GOALS -- DEVELOP EXAMPLES OF RADICAL, INNOVATIVE APPROACHES FOR EACH OPERATIONS COST DRIVER HAVING THE POTENTIAL OF CONTRIBUTING TO AN ORDER-OF-MAGNITUDE COST REDUCTION IN LCC (LIFE CYCLE COSTS).

SGO E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

CIRCA 2000 SYSTEM

PRESENTED AT
KSC
APR. 6, 1988



● SPACE OPERATIONS COST DRIVERS HANDBOOK (SOCH)

- PART 1 COST DRIVERS CHECKLISTS
- PART 2 SOCH REFERENCE INFORMATION

- OPERATIONAL REQUIREMENTS
 - CIRCA 2000 SYSTEM
 - SLSOC

- TECHNOLOGY REFERENCE APPENDIX

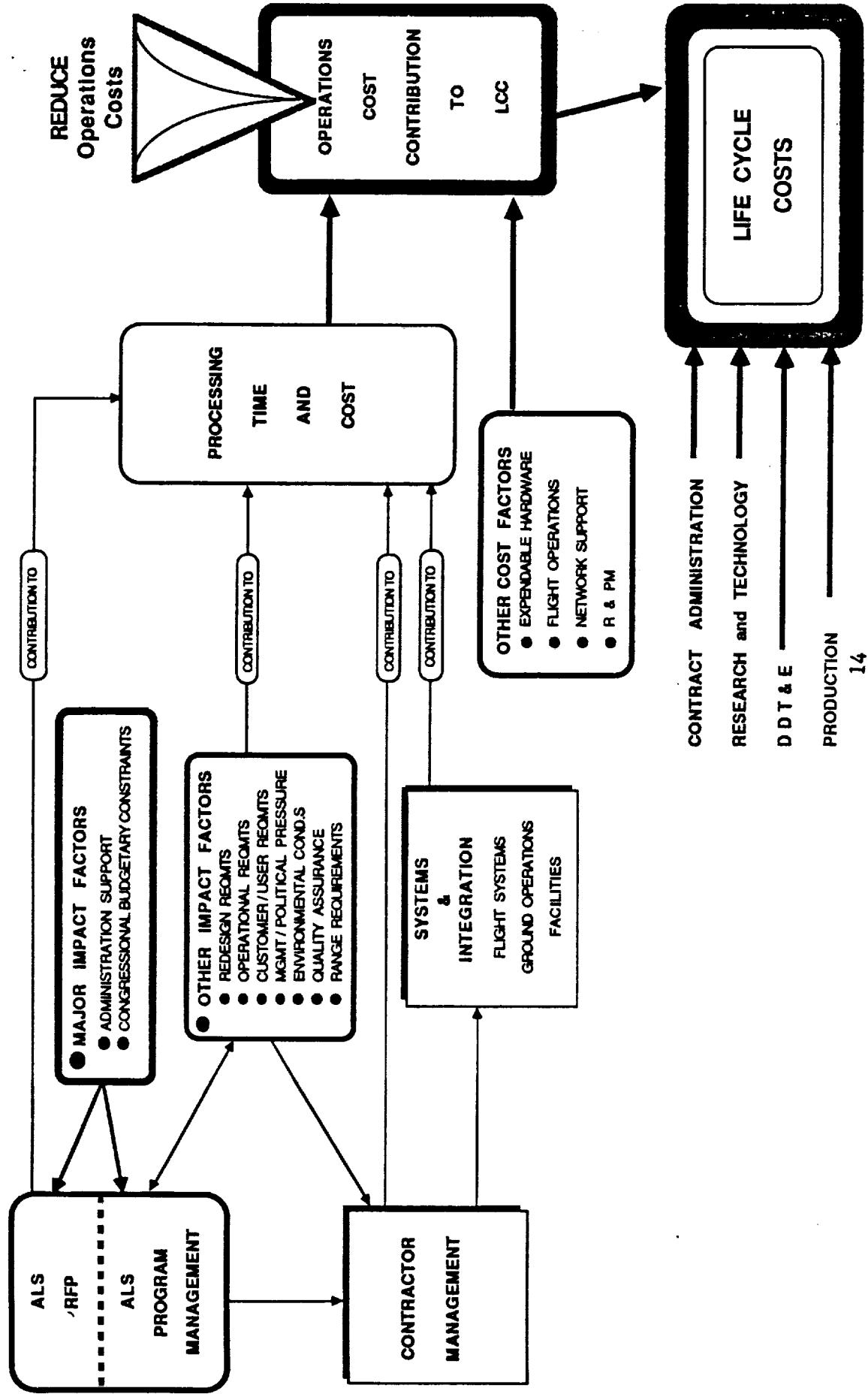
SOCH CONTENTS

PRESENTED AT
KSC
APR. 6, 1988

- PROBLEM AVOIDANCE FOR PROGRAM MANAGEMENT (27)
- SYSTEMS ENGINEERING CHECKLISTS (11)
- TECHNOLOGY CHECKLISTS (8)
- DESIGNERS CHECKLISTS (19)
- APPENDICES (Separate Volume)

COST CONTRIBUTORS

PRESNTED AT
KSC
APR. 6, 1988



SGO E&T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SIMPLIFIED LAUNCH SYSTEM
OPERATIONAL CRITERIA (SLSOC)

PRESENTED AT
KSC
APR. 6, 1988

MANAGEMENT & SYSTEM
ENGINEERING

- M 1) ● PROCUREMENT
- M 2) ● DESIGN / BUILD TEAMS
- M 3) ● DEMING STYLE MANAGEMENT
- M 4) ● LIFE CYCLE COSTS
- M 5) ● DESIGN TO COST
- M 6) ● UNIFIED LIFE CYCLE ENGINEERING
- M 7) ● RISK MANAGEMENT
- M 8) ● RELIABILITY / OPERABILITY
- M 9) ● MAINTAINABILITY / SUPPORTABILITY
- M 10) ● LOGISTICS SUPPORT
- M 11) ● OPERATIONAL TEST REQUIREMENTS
- M 12) ● QUALITY ASSURANCE
- M 13) ● SAFETY
- M 14) ● SECURITY
- M 15) ● CONNECTIVITY ARCHITECTURE

AVIONICS & SOFTWARE

- AUTONOMOUS VEHICLE
 - A 1) ● BIT / SITE (IN - BOARD CHECKOUT)
 - A 2) ● FAULT TOLERANT AVIONICS SUITE
 - A 3) ● VEHICLE HEALTH & STATUS MONITORING SYSTEM
 - A 4) ● MINIMAL LAUNCH CONTROL INTERFACE
 - A 5) ● RETURNED VEHICLE SELF - TEST FOR REFLIGHT
 - A 6) ● AUTONOMOUS G MAC
 - A 7) ● OPTICAL / IR / INF LINK ONLY TO ONE SOFTWARE FOR C/I, LAUNCH, FLIGHT
 - A 8) ● COMMON TOPOF SOFTWARE FOR C/O, LAUNCH, MISSION
- MAINTAINABILITY / SUPPORTABILITY
 - A 9) ● OPERATIONS DATA OVERLAY (C/O, LAUNCH, MISSION)

- ELIMINATE**
- A 10) ○ NEUTRIBUS
 - A 11) ○ INFORMER CONNECTS TO ONE GROUND POWER REQUIREMENTS

ELIMINATE

- M 1) ○ MULTIPLE PRIME CONTRACTORS ON SAME PROGRAM
- M 2) ○ TIGER TEAMS FOR STATUS (SEE L 1)
- M 3) ○ SEPARATE DESIGN CONTRACTORS / VOLUMINOUS INTERFACE CONTROL
- M 4) ○ LARGE QUANTITY INSPECTION TEAMS
- M 5) ○ CANNIBALIZATION
- M 6) ○ COST OVERBUNS & UNLIMITED LOC
- M 7) ○ EXORBITANT COST TO ATTEMPT ZERO RISK REQUIREMENTS

POWER

- E) ● LOW MAINTENANCE
- E) ● ENERGY STORAGE
- E) ● PROPELLANT GRADE
- F) ● FUEL CELLS
- E) ● STATE - OF - ART ENERGY SOURCES
- E) ● SYSTEM SIZED TO PROVIDE ON - BD
- P) ● PMR FOR GROUND OPERATIONS

- ELIMINATE**
- E 1) ○ SEPARABLE TPS
 - E 2) ○ ALL ORGANIC
 - E 3) ○ PROCESSING SAFETY RESTRICTIONS

STRUCTURES & MATERIALS

- E) ● IMPROVED STRUCTURE
- E) ● MINIMIZE LEAK PATHS
- E) ● STRUCTURAL INTEGRITY
- E) ● INTEGRAL TIPS
- E) ● ORDNANCE
- E) ● WEAPON IDENTIFICATION
- E) ● LASER IGNITION
- E) ● ACCELERATION / CLIMB
- E) ● SEPARATION / CLIMB
- E) ● INTIMOLE - I M - DEVICES

- ELIMINATE**
- E 1) ○ SEPARATE CHASSIS AND PMS
 - E 2) ○ HIGH MAINTENANCE TURBOPUMPS
 - E 3) ○ HYDRAULICS
 - E 4) ○ ON - BOARD PURGES
 - E 5) ○ ON - BOARD PRESSURE SYSTEM
 - E 6) ○ CANISTERED ENGINES
 - E 7) ○ EXTENSIVE RECOVERY REFRESHMENT

PROPELLUTION

- P) ● INTEGRATED PROPULSION SYSTEM
- P) ● SIMPLIFIED ROBUST PROPULSION SYSTEM
- P 1) ○ FULLY THROTTLEABLE ENGINES (MULTI-PHASE)
- P 1) ○ SOFT ENGINE START
- P 1) ○ TIC BY DELTA THRUST AND OR HEAT / CHARGE
- P 1) ○ ONE OXIDIZER / ONE FUEL
- P 2) ○ SEPARATE CHASSIS AND PMS
- P 2) ○ HIGH MAINTENANCE TURBOPUMPS
- P 3) ○ HYDRAULICS
- P 4) ○ ON - BOARD PURGES
- P 5) ○ ON - BOARD PRESSURE SYSTEM
- P 6) ○ CANISTERED ENGINES
- P 7) ○ EXTENSIVE RECOVERY REFRESHMENT

- ELIMINATE**
- P 1) ○ PAD
 - P 2) ○ BARRICADE STAGES AT PAD
 - P 3) ○ DRY WATER EXHAUST BUFFER
 - P 4) ○ LIGHTING LIGHTING TOWER
 - P 5) ○ FLY - AWAY CONNECTS ONLY
 - P 6) ○ PROPELLANT FABRI
 - P 7) ○ PAVED TOW - WAY
 - P 8) ○ MOBILE EQUIPMENT
 - P 9) ○ STANDARD AIRCRAFT TUG
 - P 10) ○ STRAPDOWN WHEELED DOLIES
 - P 11) ○ MOBILE CRANE
 - P 12) ○ BUILDINGS

FACILITIES & SUPPORT EQUIPMENT

- L 1) ● 100% COMPUTER CONNECTIVITY
- L 2) ○ AUTOMATION
- L 3) ○ ELECTRONIC DATA ACQUISITION
- L 4) ○ TEST REQUIREMENT VERIFICATION
- L 5) ○ STAGE ASSEMBLY
- L 6) ○ INITIAL NEAR LAUNCH CENTER
- L 7) ○ FINAL AT LAUNCH CENTER
- L 8) ○ HORIZONTAL PROCESSING
- L 9) ○ PAYLOADS
- L 10) ○ PAYLOADS
- L 11) ○ ONE AUTONOMOUS CONTAINER
- L 12) ○ PAD
- L 13) ○ BARRICADE STAGES AT PAD
- L 14) ○ DRY WATER EXHAUST BUFFER
- L 15) ○ LIGHTING LIGHTING TOWER
- L 16) ○ FLY - AWAY CONNECTS ONLY
- L 17) ○ PROPELLANT FABRI
- L 18) ○ PAVED TOW - WAY
- L 19) ○ MOBILE EQUIPMENT
- L 20) ○ STANDARD AIRCRAFT TUG
- L 21) ○ STRAPDOWN WHEELED DOLIES
- L 22) ○ MOBILE CRANE
- L 23) ○ BUILDINGS

ELIMINATE

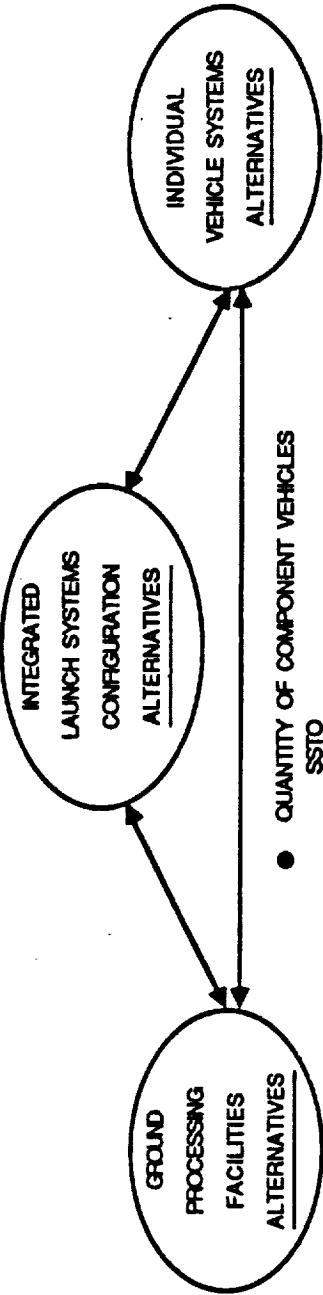
- O) ○ AUTOMATION
- L 1) ○ ISOLATED DATABASES
- L 2) ○ PAPERWORK RELATED TO TEST
- L 3) ○ REQUIREMENTS VERIFICATION
- L 4) ○ PRINTED TRANSFER OF TEXT / DATA
- L 5) ○ PAYLOAD / VEHICLE INTEGRATION
- L 6) ○ VERIFICATION TESTING
- L 7) ○ LIFTING VEHICLES CLEAR OF GROUND
- E 1) ○ GROUND POWER CRAWLER
- E 2) ○ MOBILE EQUIPMENT
- E 3) ○ CRAWLER / TRANSPORTER
- E 4) ○ MOBILE LAUNCH PLATFORM
- O) ○ BUILDINGS
- L 1) ○ VAB
- L 2) ○ VTF
- L 3) ○ VPS

- NOTE:**
- THESE ITEMS WERE CONSISTENT WITH THE PRELIMINARY ALS RFP BUT MAY NOT BE APPLICABLE TO CURRENT DESIGN CONCEPTS

ELIMINATE

- O) ○ HARDWARE CONNECTORS
- L 1) ○ ACCESS STRUCTURES
- L 2) ○ SWINGGIRLS
- L 3) ○ RETRACTING UNICRUCES
- L 4) ○ HOLD-DOWN
- L 5) ○ TEXT / DATA
- L 6) ○ DELUGE WATER SUPPRESSION WATER
- L 7) ○ FLAME TRUGHT DEFLECTOR
- L 8) ○ NO / GM 2 STORAGE
- P 6) ○ GROUND POWER
- E 1) ○ CRAWLER MAY
- E 2) ○ MOBILE EQUIPMENT
- E 3) ○ CRAWLER / TRANSPORTER
- E 4) ○ MOBILE LAUNCH PLATFORM
- O) ○ BUILDINGS
- L 1) ○ VAB
- L 2) ○ VTF
- L 3) ○ VPS

SLSOC ALTERNATIVES (VERTICAL LAUNCH ASSUMED)



- QUANTITY OF COMPONENT VEHICLES
- PROPELLANTS
 - RP-1
 - LH₂
 - CH₄
 - C₃H₈
 - SOLIDS
 - HYPERGOLS
- ON-BOARD POWER
 - FUEL CELLS
 - BATTERIES
 - COMBINATIONS
 - HYDRAULIC SUPPLY
 - APU
 - MPS
- PNEUMATICS
 - PURGE
 - VALVE CONTROL
- TEST - & - C / O
 - MANUAL
 - AUTOMATIC
 - INTEGRATED
- PRESSURIZATION
 - BOTTLES
 - AUTOGENOUS
 - MPS
- THE UNAVOIDABLE INTERRELATIONSHIPS OF
 - GROSS VEHICLE CONFIGURATION, VEHICLE SYSTEMS, AND GROUND SUPPORT PROCESSING ARE INDICATED.
 - PRELIMINARY DESIGN MUST ACCOMMODATE EXPERIENCED PERSONNEL FROM ALL THREE TO MINIMIZE LCC
- VEHICLE PROCESSING MODE ONLY
- PAYLOAD PROCESSING MODE ONLY
- PAYLOAD INTEGRATION ONLY
- VEHICLE MATE COMBINATION
- VEHICLE MATE HORIZONTAL
- VEHICLE MATE VERTICAL
- ERECTION PAD
- VAB PAD
- VEHICLE ACCESS ALL LOCATIONS
- TRANSFER TO PAD
 - OPF ONLY
 - ML/CT vs DOLLIES
 - BARGE
 - LANDING GEAR
 - ERECTOR/TRANSPORTER RAIL
 - PAD SYSTEMS

SIMPLIFIED LAUNCH SYSTEM
OPERATIONAL CRITERIA
SAMPLE DATA SHEET

PRESENTED AT
KSC
APR. 6, 1988

NO: xx Corresponds to the Operations Requirement number on the SLSOC chart:

- M - Management & System Engineering
- A - Avionics & Software
- E - Power
- S - Structures & Materials
- P - Propulsion
- L - Facilities & Support Equipment

Title: A cryptic description of the SLSOC Operations Requirement for which:

- Management / Engineering Systems:
 Needing implementation to drastically reduce related Cost Drivers
- Hardware related:
 Indicates the system or device, which must be changed or eliminated to drastically reduce related Cost Drivers.

Operations Requirement: A short statement of the SLSOC.

Rationale:

A description, derived from past experience which made this item a Cost Driver.

Sample Concept:

Represents an example concept which might result from "brainstorming" a potential solution for the Cost Driver.

Technology Requirement: Indicates related "technology" (existing or near-term) which might be used in the solution.

Technology References: List of NASA/RECON or DIALOG numbers referring to the Phase 2 Final Report, Volume 5, Technology References, which includes the abstract of each.

SIMPLIFIED LAUNCH SYSTEM
OPERATIONAL CRITERIA
On-Board Checkout

PRESENTED AT
KSC
APR. 6, 1988

No: A 1

Operations Requirement:

Current configurations require extensive use of GSE to support vehicle checkout. Future systems should incorporate onboard checkout and minimize (preferably eliminate) GSE.

Vehicles should have sufficient self-test capability to verify flight readiness or isolate problem to LRU.

Rationale:

Current configurations require complex GSE hookups to support system test and operational verification. The configuration verification, required for test hookup and calibration, defeats efficient operations.

To accomplish order-of-magnitude cost reduction, we must achieve 160-Hr or better turnaround time for recoverable stages. (160-Hrs was the original STS Turnaround goal whose actuals have grown an order-of-magnitude). In addition to turnaround times exceeding 1500 hours, aging recoverable vehicles will impose requirements for structural inspections which will require extensive time periods offline.

ELV's must have comparable processing times.

Vehicles should be capable of launch by meeting "Minimum Equipment List" similar to commercial airline approach.

SIMPLIFIED LAUNCH SYSTEM
OPERATIONAL CRITERIA
On-Board Checkout - (Cont'd)

PRESENTED AT

KSC

APR. 6, 1988

Sample Concept:

After a firm set of test requirements has been defined early in the design phase, the associated hardware/software required to support on-board testing must be incorporated in each subsystem. It is important to maintain subsystem self-test autonomy.

BIT identifies and records anomalies during flight. After landing, BIT/BITE isolates problem to LRU level. After replacement, BIT/BITE retests and verifies flight readiness. Ideally, recoverable vehicles would include sensors for complete structural integrity to avoid extensive downtimes.

Technology Requirement:
Further development of Vehicle Health Monitoring System (VHMS) with BIT/BITE to meet specific requirements. Development of structural sensors including corrosion.

Technology References: (FROM NASA RECON)

87N10079, 87A33872, 87A32118, 86N20489, 86A32796, 86A31260,
86A30591, 86A23765, 85X77042, 85X70467, 85N20697, 85N16753,
85N16897, 85N16898, 85N16900, 85N11594, 85N13194, 85A45082,
85A28633, 85N34596, 85A45975, 85A45398, 85A26804, 85A24795,
85N22528, 84X76865, 84X74856, 84X71619, 84N14754, 84N26573,
84N34500, 84A46661, 83A49578, 83A45473

SGO ET STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

EXAMPLE RECON ABSTRACT
NO. 1

87N10079# ISSUE 1 PAGE 13 CATEGORY 6 86/02/00 17 PAGES UNCLASSIFIED DOCUMENT DCAFE070125

UTTL: Experience with the Onboard Checkout And Monitoring System (OCAMS) of a military aircraft resulting improvements and the consequence for future design.

AUTH: A/NUMBERGER, K.; B/PROBST, K.

CORP: Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

SAP: Avail: NTIS HC A25/MF A01; DFVLR, Cologne, West Germany, DM 150; In DFVLR Proceedings of the 13th Symposium on Aircraft Integrated Data Systems p 75-92 (SEE N87-10075 01-06)

CIO: GERMANY,FEDERAL REPUBLIC OF

MAJS: /AIR DATA SYSTEMS/ *AVIONICS/ *CHECKOUT/ *ENGINE MONITORING INSTRUMENTS/
*MILITARY AIRCRAFT

MINS: /AIRCRAFT DESIGN COMPUTER SYSTEMS DESIGN/ONBOARD DATA PROCESSING
ABA: ESA

ABS: The Onboard Checkout and Monitoring System was designed to provide for test and diagnosis of defects to avionic and certain nonavionic equipments. Experience showed what could be improved. Engine and structure monitoring must be improved, still more information would be useful to store, and it was realized that the high sensitivity of the BIT detected also very transient faults. In order to cover these problems, the data acquisition unit of the crash recorder system will be extended with an engine and structural life monitoring system. Using the opportunity of introducing a data communication bus into the avionic system, facilities for data collection, correlation, and event monitoring will be initiated. Based on this the principal structure of the monitoring and test systems of future aircraft can be designed.

SG O/E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

EXAMPLE RECON ABSTRACT
NO. 2

85N16753# ISSUE 8 PAGE 1066 CATEGORY 60 84/10/00 6 PAGES UNCLASSIFIED DOCUMENT

UTTL: Hardware/software codesign for maintainable systems

AUTH: A/FRANK, G. A.

CORP: Research Triangle Inst., Research Triangle Park, N.C.; AVAIL. NTIS

SAP: HC A13/MF A01; In AGARD Design for Tactical Avionics Maintainability 6 p (SEE N85-16731 08-01)

CIO: UNITED STATES

MAJS: /"ARCHITECTURE (COMPUTERS)/*COMPUTER AIDED DESIGN/*COMPUTER SYSTEMS PROGRAMS/
*COMPUTERS/*HARDWARE/*INFORMATION THEORY/*INTERFACES

MINS: / COMPUTER PROGRAMS/ DATA PROCESSING EQUIPMENT/ GRAPHS (CHARTS)/ LOGIC DESIGN
MACHINE TRANSLATION MAINTENANCE/ MILITARY TECHNOLOGY/ PETRI NETS/ PRODUCT DEVELOPMENT
ABA: E.A.K.

ABS: The codesign of software/hardware which can improve the maintainability of military systems is discussed. The following methods are outlined: (1) support of the design verification process to make it more complete and less costly; (2) reduction of the cost of a system modification by providing accurate, machine readable documentation of the system design; and (3) support of the detection, isolation, and correction of faults on both software and hardware. Development of techniques for software/hardware codesign of high performance signal processors is examined. The methodology is based on the representation of both software and hardware as directed graphs. The system of computer aided design (CAD) tool that support this methodology is the architecture design and assessment system (ADA). The system has two types of components: graph processing modules, which can be applied to any graph, and interfaces to specialized tools, which operate on specific kinds of graphs. The graph processing tools include an interactive graphics editor, a library manager, a Petri net analysis tool, and a Petri net simulator. The interfaces include an HDL interface, and Ada interface, and a reliability tool interface.

EXAMPLE RECON ABSTRACT
NO. 3

PRESENTED AT
KSC
APR. 6, 1988

85A24795*# ISSUE 10 PAGE 1347 CATEGORY 18 85/02/00 4 PAGES UNCLASSIFIED DOCUMENT

UTTL: Expanding role for autonomy in military space

AUTH: A/EVANS, D. D.; B/GAJEWSKI, R. R. PAA: A/(California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA); B/(USAF, Space Technology Center, Kirtland AFB, NM)

CORP: Jet Propulsion Lab., California Inst. of Tech., Pasadena; Air Force Space Technology Center, Kirtland AFB, N. Mex.

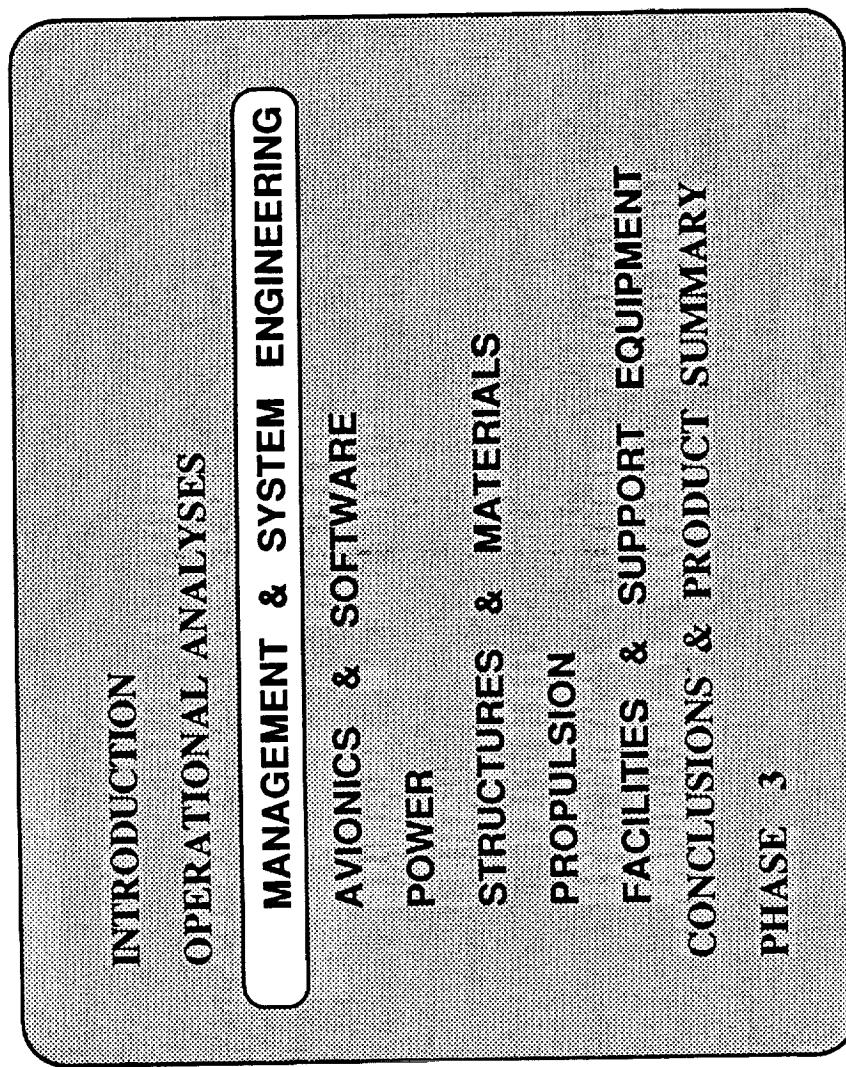
CIO: UNITED STATES; Aerospace America (ISSN 0740-722X), vol. 23, Feb. 1985, p. 74-77.

MAJS: /AUTONOMY/*MILITARY SPACECRAFT

MINS: /AIRBORNE/ SPACEBORNE COMPUTERS/ ARTIFICIAL INTELLIGENCE/ EXPERT SYSTEMS/ FAULT TOLERANCE/ ONBOARD DATA PROCESSING

ABA: M.S.K.

ABS: The Jet Propulsion Laboratory is currently transferring satellite on-board autonomy technology to the USAF for use in military spacecraft as a means of lowering the ground support requirements. The techniques were proven on the Viking and Voyager spacecraft and permitted on-board fault detection and correction. New military satellites will incorporate an autonomous redundancy and maintenance management subsystem in an on-board computer, while the system will still be subject to ground-based safing commands for situations demanding deeper analyses. A level 5 autonomy will need 256 kb memory, 10 Mb non-volatile data storage and 50 W power and will weigh 20 kg. Systems will be periodically checked and compared with an ideal in the data base. Deviations detected will result in a rollback and redundant examination by two microprocessors, which can initiate correction commands until operational criteria are met. The development of the expert systems to the point that they satisfy military specifications is expected to take 10 yrs.



SIMPLIFIED LAUNCH SYSTEM OPERATIONAL CRITERIA
MANAGEMENT & SYSTEM ENGINEERING

PRESENTED AT

KSC

APR. 6, 1988

- M 1) ● PROCUREMENT
- M 2) ● DESIGN / BUILD TEAMS
- M 3) ● DEMING STYLE MANAGEMENT

- M 4) ● LIFE CYCLE COSTS
- M 5) ● DESIGN TO COST
- M 6) ● UNIFIED LIFE CYCLE ENGINEERING
- M 7) ● RISK MANAGEMENT
- M 8) ● RELIABILITY / OPERABILITY
- M 9) ● MAINTAINABILITY / SUPPORTABILITY
- M 10) ● LOGISTICS SUPPORT
- M 11) ● OPERATIONAL TEST REQUIREMENTS
- M 12) ● QUALITY ASSURANCE

ELIMINATE

- M 1) ○ MULTIPLE PRIME CONTRACTORS
ON SAME PROGRAM
- M 6) ○ TIGER TEAMS FOR STATUS (SEE L 1)
(Requires 100% Computer Connectivity)
- M 1) ○ SEPARATE DESIGN CONTRACTORS /
VOLUMINOUS INTERFACE CONTROL
LARGE QUALITY INSPECTION TEAMS
- M 12) ○ CANNIBALIZATION
- M 10) ○ COST OVERRUNS & UNLIMITED LCC
- M 4) ○ EXORBITANT COST TO ATTEMPT
ZERO RISK REQUIREMENTS

SLSOC
Procurement

PRESENTED AT
KSC
APR. 6, 1988

No: M 1

Operations Requirement:

Government procurement must utilize a contracting mode that establishes prime contractors with sufficient system integration authority to define system (hardware and software) configuration requirements. This will enable cost-effective management for the total system architecture (including hardware acceptance and sub-contractor control).

Rationale:

Contracts that specify GFE, such as engines, and dictate detailed specifications rather than end product performance severely limit a prime contractor's ability to achieve the optimum design or manage the job in a cost effective manner. Most detail hardware specifications limit the contractor's capability to be innovative and cost effective.

FOR:

Sample Concept:
Technology Requirements:
Technology References:

See FINAL REPORT, Vol. 4

No. M 2

Operations Requirement:

Beginning with the conceptual definition through the design phase, integrate the experience and knowledge of specialists in all areas, including manufacturing, procurement, ground operations, etc.

Rationale:

As a result of compartmentalized organization responsibilities, past vehicle designs have not fully utilized and integrated the knowledge and experience of specialists in all functional organizations.

The past sequence of hardware development, whereby the hardware designer completes his design (without input from manufacturing, purchasing, operations, etc.) and "throws it over the fence", for the other organizations to do the best they can in producing and operating the hardware in a cost-effective way, has led to life cycle cost an order-of-magnitude higher than necessary.

FOR: Sample Concept:
Technology Requirements:
Technology References:

See FINAL REPORT, Vol. 4
26

No: M 3

Operations Requirement:

Traditional compartmented management style must be replaced with Deming-type, team-style management with integrated quality.

Rationale:

In maturing over the past twenty-five years, aerospace management, both in and out of government, have succumbed to bureaucratic disease whereby the first consideration of any management or technical problem is how it will affect the "status quo". If the effect is negative in any way, the answers are often skewed preventing top management from making cost effective decisions. Top management also suffers from biased decisions made to accommodate their "status quo".

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

SLSOC
Life Cycle Costs (LCC)

No: M 4

Operations Requirement:
Operations efficiency must be considered during concept development and design.

Rationale:

Operations requirements have been disregarded in the past because they are brought up too late in the design cycle to be implemented in a cost-effective manner.

For Example (FY-85 Operations Costs For 8 Flights):

SRB	\$464.2m	Flight Ops	\$345.3m
ET	415.8m	Orbiter Hdwe	162.6m
		Crew Equip.	36.3m
		SSME	51.6m
		Contract Admin.	17.1m
		Subtotal	\$1894.8m
		Plus Network Support	\$ 20.4m
		R & PM	274.2m
		FY-85 Total Cost	<u>\$2189.4M (or \$ 273.5M per flight)</u>

Minimizing upfront program costs multiplies Life Cycle Cost.

FOR: Sample Concept:
Technology Requirements:
Technology References:] - See FINAL REPORT, Vol. 4
28

SLSOC
Design to Cost

PRESENTED AT
KSC
APR. 6, 1988

No: M 5

Operational Requirement:

Assure that adequate Design-to-Cost budget is allocated to operational considerations such as maintainability / supportability.

Rationale:

The history of previous programs is fraught with Life Cycle Cost extravagances caused by inadequate front-end budget considerations for operations related design.

FOR: Sample Concept:
Technology Requirements:
Technology References:
] See FINAL REPORT, Vol. 4

No: M 6

Operations Requirement:

Use Unified Life Cycle Engineering (ULCE). This is a design engineering environment in which computer-aided design technology is used to continually assess and improve the quality of a product during the active design phases as well as throughout its entire life cycle. This is accomplished by integrating and optimizing design attributes for producibility and supportability with design attributes for performance, operability, cost, and schedule.

Rationale

No integrated methodology or discipline has been used to provide advantageous computerized integration of the procedures dealing with designing for producibility and design for supportability -- with those dealing with designing for performance, cost, and schedule.

FOR: Sample Concept:
Technology Requirements:
Technology References:

See FINAL REPORT, Vol. 4

No: M 7

Operational Requirement:

The unmanned ALS program requires compliance with a non-emotional, well-engineered risk management program.

Rationale:

Trying to provide a "zero-risk" launch program is like dividing cost by zero.

The emotionalism and overreaction to the loss of Challenger, has impacted the STS program far more than a logical risk management program. In addition to the two plus years of manifests that were lost, future vehicle processing times have tripled from the pre-Challenger goal.

Launch readiness decisions must be made by technically qualified managers based on a disciplined test and qualification requirements compliance database.

FOR: Sample Concept:
Technology Requirements:
Technology References:
See FINAL REPORT, Vol. 4

No: M 8

Operational Requirement:

To provide a vehicle with adequate system availability, resiliency, and schedule dependability in order not to impact schedule and resulting processing cost (i.e. manpower and overtime).

Rationale:

The processing history at ETR and KSC of both expendable and recoverable vehicles support this requirement.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

S G O E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SLSOC
Maintainability/Supportability

PRESENTED AT

KSC

APR. 6, 1988

No: M 9

Operational Requirement:
Maintainability / supportability must get high priority in Design / Build Team representation.

Rationale:

Analysis of STS cost drivers in Phase 1 of this study includes, for example, documentation of some 226 maintainability issues and 104 accessibility issues. Most of these would not have occurred if adequate consideration / priority had been assigned before the design was cast in concrete.

FOR: Sample Concept:
Technology Requirements:
Technology References:
See FINAL REPORT, Vol. 4

SLSOC
Logistics Support

No: M 10

Operational Requirement:
Provide adequate spares provisioning from the beginning.

Rationale:

Spare parts provisioning is yet another illustration that the Shuttle Program was not prepared for an operational schedule. The conscious decision was made to postpone spare parts procurements in favor of budget items of perceived higher priority. The policy proved to be shortsighted and has led to the inefficiencies of cannibalization to support the flight rate.

From the Challenger Presidential Commission Report, "The logistics support for 51-L ground processing was inadequate, since it created a need to remove parts from other orbiters to continue 51-L operations. For 51-L, 45 out of approximately 300 required parts were cannibalized. These parts ranged from bolts to an OMS TVC actuator and a fuel cell. The significance to operations of cannibalization is that it creates (1) significantly increased efforts to accomplish the same work due to multiple installation and retest requirements, (2) schedule disruption due to added work and normally later part availability, and (3) orbiter damage potential due to increased physical activity in the vehicles. These efforts make cannibalization operationally unacceptable."

FOR: Sample Concept:
Technology Requirement:
Technology References:

See FINAL REPORT, Vol. 4

SLSOC
Operational Test Requirements

PRESENTED AT
KSC
APR. 6, 1988

No: M 11

Operational Requirement:

Valid operational test requirements should be defined by the Design/Build Team (see M2) and integrated into VHMS (Vehicle Health Monitoring System) where possible.

Rationale:

Current and past LV programs, at both ETR and KSC, test and retest at the instigation of individual design, test, and technical management organizations (Contractor, NASA, and Aerospace). All of these practice CYA to extreme levels. Further, "once a test, always a test", with little or no effort made to remove requirements for tests that are no longer necessary. Many of these tests are the result of inadequate incorporation of operations experience in the design and many qualification test requirements are carried into operations as basic test requirements unnecessarily.

Even where the design includes self-test capability, old habits die hard. For example, on IUS, pre-deployment checkout utilizes a VHMS and verifies IUS readiness for deployment in approximately two minutes. Equivalent ground testing requires extensive manpower and GSE which manually sequences each test step, with serial, manpower-intensive data analysis. Each time the IUS is moved, it is retested in this manner. The result is many additional weeks of test time.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: M 12

Operational Requirement:

A modern QA program that virtually eliminates the requirement for a large force of Quality inspectors with its inherent inefficiencies impacting processing times and costs.

Rationale:

Quality Assurance places emphasis on inspection. As a result of the Challenger loss and the Presidential Commission Report, program management has amplified this problem by increased manpower and efforts to inspect quality into the product. American industry, led by Japan's implementation of Deming's methods, is beginning to understand that inspection is not only costly, but also ineffective.

FOR: Sample Concept:
Technology Requirement:
Technology References:

See FINAL REPORT, Vol. 4

No: M 13

Operations Requirement:

Special safety requirements, particularly for ordnance and propellant related items, must be reduced to a bare minimum and preferably eliminated where possible.

Rationale:

Hazardous operations and conditions in the vehicle preparation area greatly affect operations times and increase costs. During such times, technicians are prevented from doing useful work on the vehicle, and only one task can proceed at any one time. To minimize these delays, ordnance operations must be absolutely minimized and preferably eliminated from the processing flow.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: M 14

Operational Requirement:
Security requirements which impact costs (most do) should be minimal and realistic.

Rationale:

Operational costs for past and current programs have been significantly impacted by security requirements; cost impact data was not available or considered. This cost impact includes security control and accountability of paperwork; controlled access areas; screenrooms; equipment that meets Tempest requirements; separate software; etc.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

SLSOC
Connectivity Architectures

PRESENTED AT
KSC
APR. 6, 1988

No: M 15

Operational Requirement:

Conform to computer interface standards to allow complete connectivity, both text and graphics, between organizations (Design, Manufacturing, Logistics, Operations, etc.).

Rationale:

Current methods of information flow are inadequate and error prone.

Connectivity architecture is rapidly becoming available that allows ready interchange of data among different computer operating systems and databases.

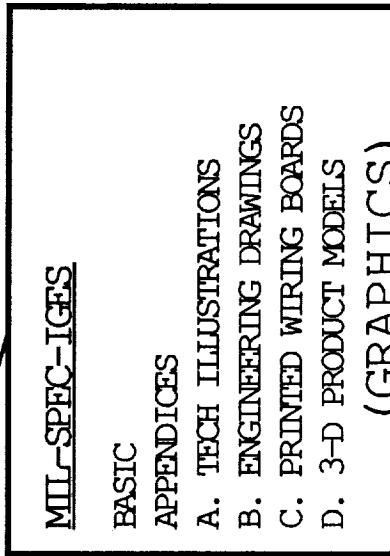
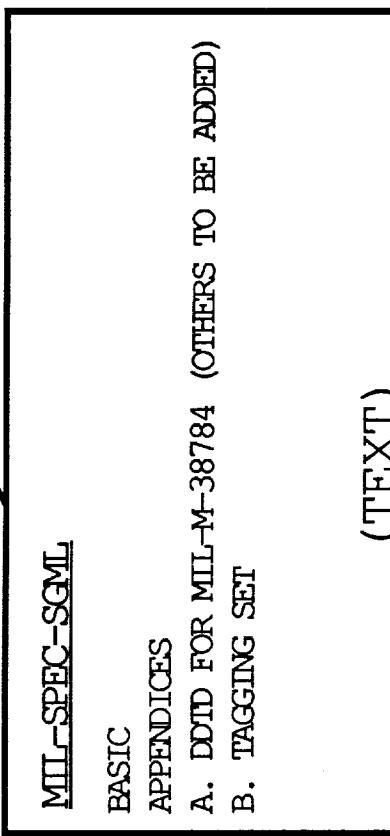
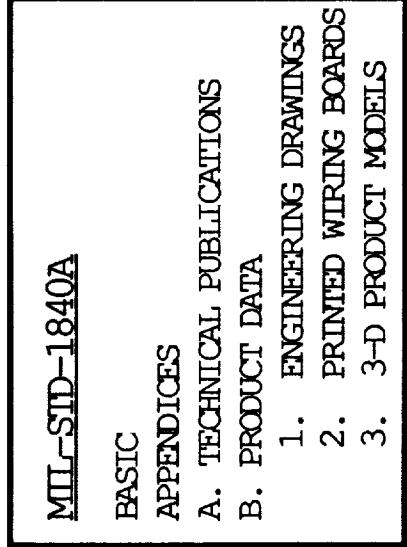
Significant cost reduction in LCC can be made by contractual requirement to utilize industry/government standards shown on the next two charts.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

STRUCTURE OF MIL-STD-1840A

PRESENTED AT
KSC
APR. 6, 1987

IDSS IMPLEMENTED BY THIS NEW MIL-STD

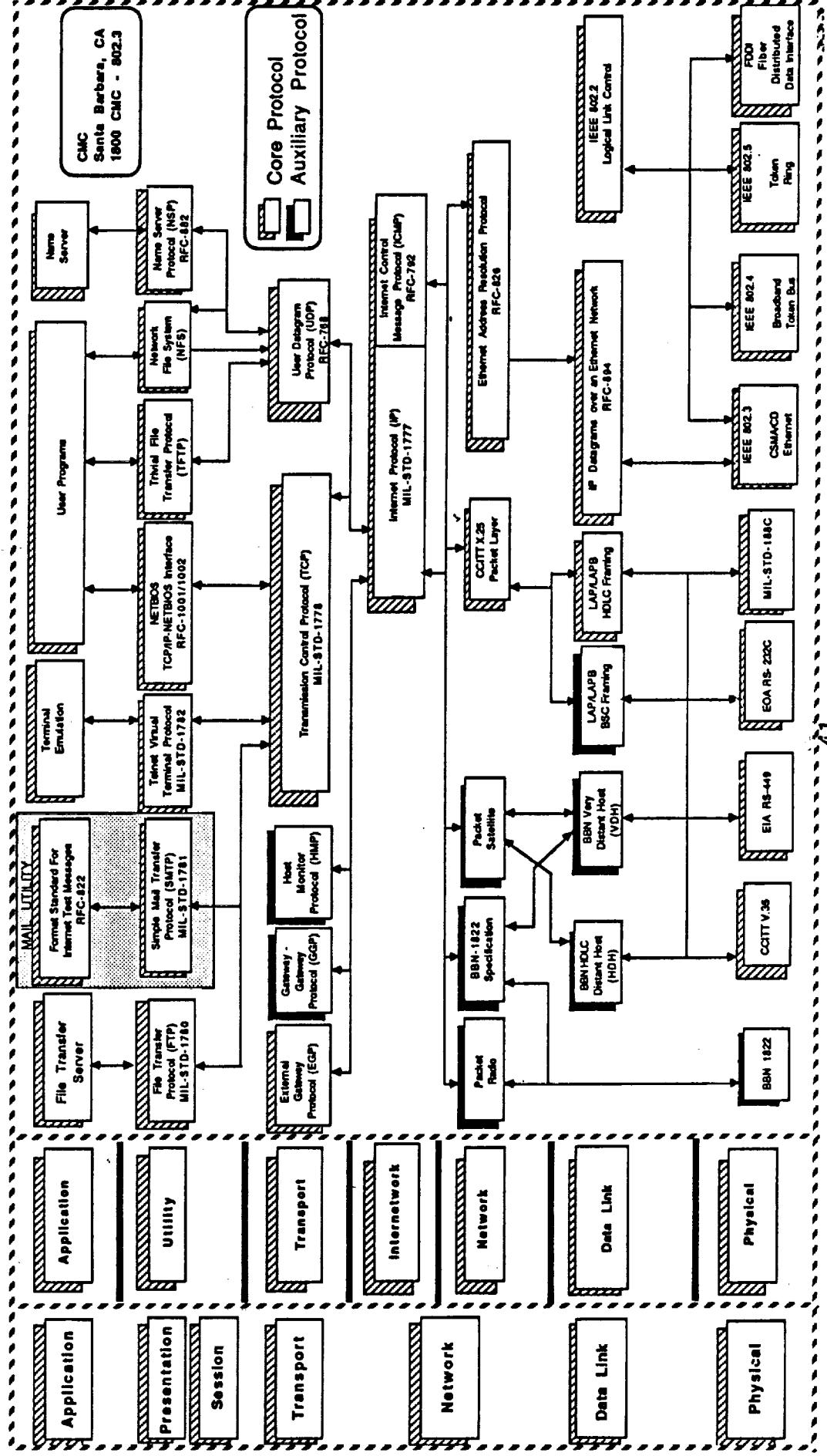


DoD INTERNET ARCHITECTURE

PRESENTED AT
KSC
APR. 6, 1988

OSI Model

DoD Model

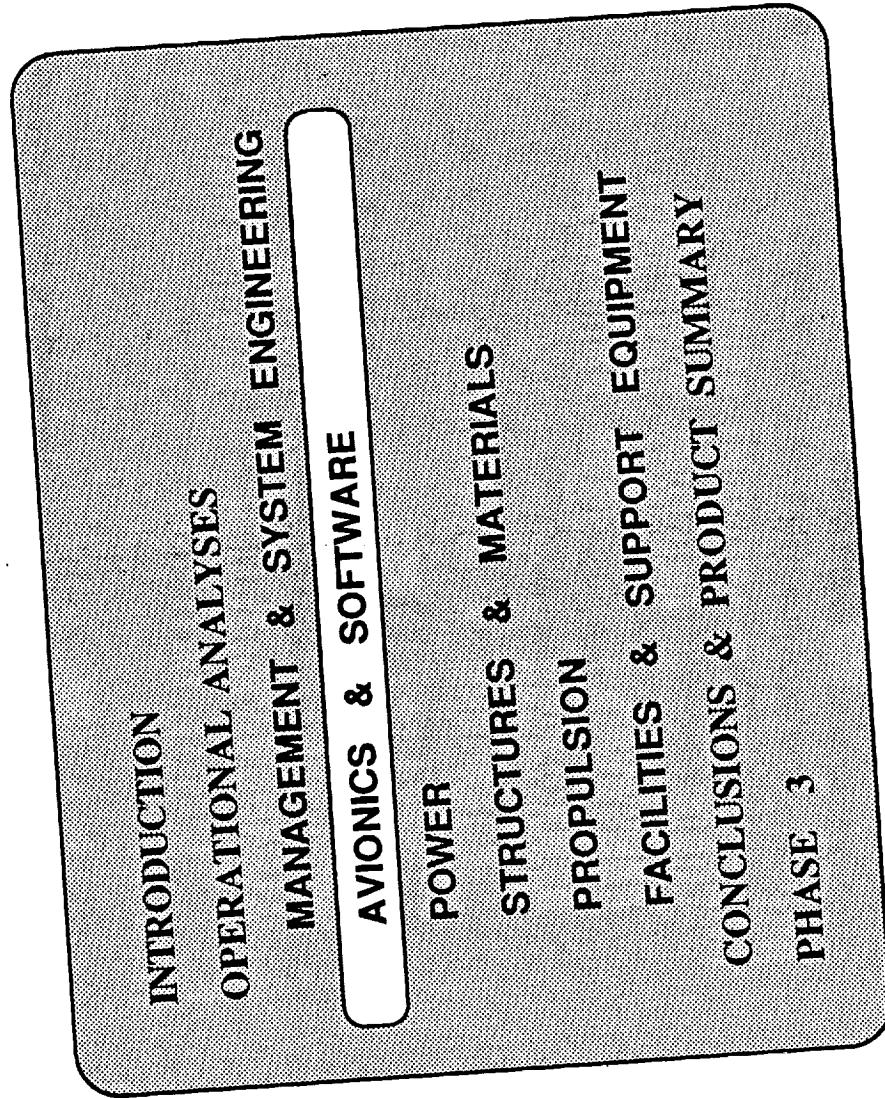


NO FACING PAGE TEXT

SGO/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES STUDY
PHASE - 2 FINAL PRESENTATION

PRESENTED AT
KSC
APR. 6, 1988



SIMPLIFIED LAUNCH SYSTEM OPERATIONAL CRITERIA
AVIONICS & SOFTWARE

PRESENTED AT
KSC
APR. 6, 1988

● AUTONOMOUS VEHICLE

- A 1) ● BIT / BITE (ON - BOARD CHECKOUT)
- A 2) ● FAULT TOLERANT AVIONICS SUITE
- A 1) ● VEHICLE HEALTH & STATUS MONITORING

SYSTEM

- A 4) ● MINIMAL LAUNCH CONTROL INTERFACE
- A 1) ● RETURNED VEHICLE SELF - TEST FOR REFLEIGHT
- A 3) ● AUTONOMOUS G N & C
- A 4) ● OPTICAL / IR / RF LINK ONLY TO GSE

● SOFTWARE

- A 5) ● COMMON "CORE" SOFTWARE
FOR C / O, LAUNCH, FLIGHT
- A 5) ● OPERATIONS DATA OVERLAYS

ELIMINATE
(C / O, LAUNCH, MISSION)

NOTE:

These items were consistent
with the preliminary ALS RFP
but may not be applicable to
current design concepts

- A 6) ○ RELATED GSE
- A 4) ○ HARDWIRE CONNECTS TO GSE
- E 1) ○ GROUND POWER REQUIREMENTS

SLSOC
On-Board Checkout

PRESENTED AT
KSC
APR. 6, 1988

No: A 1

Operations Requirement:

Current configurations require extensive use of GSE to support vehicle checkout. Future systems should incorporate onboard checkout and minimize (preferably eliminate) GSE.

Vehicles should have sufficient self-test capability to verify flight readiness or isolate problem to LRU.
Rationale:

Current configurations require complex GSE hookups to support system test and operational verification. The configuration verification, required for test hookup and calibration, defeats efficient operations.

To accomplish order-of-magnitude cost reduction, we must achieve 160-Hr or better turnaround time for recoverable stages. (160-Hrs was the original STS Turnaround goal whose actuals have grown an order-of-magnitude). In addition to turnaround times exceeding 1500 hours, aging recoverable vehicles will impose requirements for structural inspections which will require extensive time periods offline.

ELV's processing times would also be enhanced by use of on-board checkout capabilities.

FOR: Sample Concept:
Technology Requirements:
Technology References:
See FINAL REPORT, Vol. 4
45

No: A 2

Operations Requirement:

Avionics systems must provide for higher reliability by providing levels of fault tolerance in support of mandated system availability.

Rationale

To support onboard checkout and mission success the entire avionics suite must be designed to provide that level of fault tolerance required to assure that the system is available when required. This is best accomplished by assuring the robustness of all mission critical systems, and providing fault tolerance where it is required.

FOR Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

S G O E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SLSOC
Title: Autonomous GN&C
by BOEING

PRESNTED AT

KSC

APR. 6, 1988

No: A 3

Operations Requirement:

Eliminate vehicle dependence on GN&C GSE for test and checkout..

Rationale:

On-board Vehicle Health Monitoring System (VHMS) for GN&C can
eliminate / simplify / speed-up ground operations.

FOR: Sample Concept:
Technology Requirements:
Technology References:

See FINAL REPORT, Vol. 4

No: A 4

Operations Requirement:

Minimize hardwire connections to vehicle to simplify vehicle erection
and pad connection sequence. Also, drastically reduce quantity of control
and data functions from Launch Control Center to pad. Eliminate requirement
for ground power.

Rationale:

All systems must be dramatically reduced or simplified to achieve required
cost reduction. O&M of vehicle hard connects is costly and labor intensive.

FOR: Sample Concept:
Technology Requirement:
Technology References:

See FINAL REPORT, Vol. 4

No: A 5

Operational Requirement:

The vehicle should utilize the same software for ground operations test and integration as for flight.

Rationale:

Current STS ground operations are accomplished with several different programs depending on the stage of testing. This results in many hours of time for reloading the main computer memory. For example the final prelaunch load requires 14 clock-hours to accomplish.

FOR: Sample Concept:
Technology Requirement:
Technology References: } See FINAL REPORT, Vol. 4

No: A 6

Operational Requirement:

Minimize (preferably
eliminate) GSE that is in direct support of
vehicle systems.

Rationale:

Every item of GSE requires a small army in support (engineers,
technicians, mechanics, inspectors, clerks, etc.). All of these contribute
to processing time and cost.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

50

SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES STUDY
PHASE - 2 FINAL PRESENTATION

PRESENTED AT
KSC
APR. 6, 1988

-
- INTRODUCTION
 - OPERATIONAL ANALYSES
 - MANAGEMENT & SYSTEM ENGINEERING
 - AVIONICS & SOFTWARE
 - POWER
 - STRUCTURES & MATERIALS
 - PROPULSION
 - FACILITIES & SUPPORT EQUIPMENT
 - CONCLUSIONS & PRODUCT SUMMARY
 - PHASE 3

SIMPLIFIED LAUNCH SYSTEM OPERATIONAL CRITERIA
POWER

PRESENTED AT
KSC
APR. 6, 1988

- E) ● LOW MAINTENANCE
- ENERGY STORAGE
- E) ● PROPELLANT GRADE
- FUEL CELLS
- E) ● STATE - OF - ART
- ENERGY SOURCES
- E) ● SYSTEM SIZED TO
- PROVIDE ON - BD
- PWR FOR GROUND
- OPERATIONS

ELIMINATE

- A 6) ○ RELATED GSE
- E) ○ GROUND POWER REQMTS

Eliminate Requirement for Ground Power

No: E

Operational Requirement:

Vehicle systems that operate off vehicle power without requirement for ground power connection at any time during checkout or launch operations.

Onboard power source capable of providing sufficient power for ground O&M, T&C/O, and launch operations without connection to facilities or GSE.

Provide a low maintenance, state-of-the-art energy storage source. If energy source is H₂-O₂ fuel cell, then it should use propellant-grade cryos.

Rationale:

The requirement for ground power not only requires complex GSE, but also requires umbilical connections and, in some cases, towers and swingarms. Each of these require extensive checkout time and personnel (engineers, technicians, mechanics, inspectors, and clerks) in support.

Requirement for special high-grade H₂ and O₂ for fuel cells creates additional logistics, GSE, personnel, and timeline needs.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4
T53

NO FACING PAGE TEXT

SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES STUDY
PHASE - 2 FINAL PRESENTATION

PRESENTED AT
KSC
APR. 6, 1988

- INTRODUCTION
- OPERATIONAL ANALYSES
- MANAGEMENT & SYSTEM ENGINEERING
- AVIONICS & SOFTWARE
- POWER
- STRUCTURES & MATERIALS**
- PROPELLION
- FACILITIES & SUPPORT EQUIPMENT
- CONCLUSIONS & PRODUCT SUMMARY
- PHASE 3

SIMPLIFIED LAUNCH SYSTEM OPERATIONAL CRITERIA STRUCTURES & MATERIALS

PRESENTED AT
KSC
APR. 6, 1988

● IMPROVED STRUCTURE

- S 1) ● MINIMIZE LEAK PATHS
- S 2) ● STRUCTURAL INTEGRITY VERIFICATION
- S 3) ● INTEGRAL TPS
- S 4) ● ORDNANCE
- S 4.1) ● WEAPON DESTRUCT
- S 4.2) ● LASER IGNITION
- S 4.3) ● ACCELERATION / CLEVIS SEPARATION
- S 4) ● NITINOL / E - M DEVICES

ELIMINATE

- S 3) ○ SEPARABLE TPS
- S 4) ○ ALL ORDNANCE
- S 4) ○ PROCESSING SAFETY RESTRICTIONS

NOTE:

These items were consistent with the preliminary ALS RFP but may not be applicable to current design concepts.

S G O E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SLSOC

Minimize Leak Paths

No: S 1

Operations Requirement:

Develop systems with fewer separable connections and leakpaths in integrated systems.

Rationale:

Contemporary tankage and plumbing are leak sensitive and require constant ground operations vigilance. Any configuration simplification has positive consequences on ground support operations. Possible weight savings.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: S 4

Operations Requirement:

Eliminate all ordnance devices or provide ordnance which is inherently safe for handling purposes. Ordnance elements, if required, must be introduced into the processing flow with the minimum possible impact. The objective would be to eliminate or drastically reduce "area clear" requirements levied by ordnance activities.

Rationale:

There are five types of ordnance devices currently used on STS:
propulsion (SRM's), ignition, release, separation, and range safety.
The special handling, safety, area clear, and training requirements make this a major cost area in ground processing.

FOR: Sample Concept:
Technology Requirements:
Technology References:
See FINAL REPORT, Vol. 4

SI SOC
Independent Weapon Destruct

KSC

APR. 6, 1988

No: S 4.1

Operations Requirement:

Provide ground-based anti-missile-type battery of circa 1995 weapon destruct. Eliminate extensive systems to provide near-range vehicle for "area clear" during range safety ordinance non-productive manhours for "safety army" and procedures that accommodate installation. Minimize "safety army" and contemporary systems and methods.

Rationale:

Elimination of vehicle range safety ordinance and associated non-productive manhours and operational cost is highly desirable. Consider current range safety regulations negotiable.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: S 4.2

Operational Requirement:
Eliminate pyrotechnic type ordnance where possible; at least, provide system with less stringent safety requirements.

Rationale:

There are four types of ordnance devices currently used on STS: ignition, release, separation, and range safety. The special handling safety, area clear, and training requirements make this a major cost area in ground processing.

FOR: Sample Concept:
Technology Requirement:
Technology References: } See FINAL REPORT, Vol. 4

SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES STUDY
PHASE - 2 FINAL PRESENTATION

PRESENTED AT

KSC

APR. 6, 1988

- INTRODUCTION
- OPERATIONAL ANALYSES
- MANAGEMENT & SYSTEM ENGINEERING
- AVIONICS & SOFTWARE
- POWER
- STRUCTURES & MATERIALS
- PROPELLION**
- FACILITIES & SUPPORT EQUIPMENT
- CONCLUSIONS & PRODUCT SUMMARY
- PHASE 3

SIMPLIFIED LAUNCH SYSTEM OPERATIONAL CRITERIA
PROPELLION

PRESENTED AT
KSC
APR. 6, 1988

● INTEGRATED PROPULSION
SYSTEM

P1) ● SIMPLIFIED ROBUST PROPULSION
SYSTEM

- P1.1) ● FULLY THROTTLEABLE
ENGINES (MULTI-PHASE)
- P1.2) ● SOFT ENGINE START
- P1.3) ● TVC BY DELTA THRUST AND/
OR RCS/ OR AERO
- P1.4) ● ONE OXIDIZER / ONE FUEL

ELIMINATE

- P 2) ○ SEPARATE OMS AND RCS
- P 3) ○ HIGH MAINTENANCE
- TURBOPUMPS
- P 4) ○ HYDRAULICS
- P 5) ○ HYPERGOLS
- P 6) ○ GN₂ / He ON-BOARD PURGES
- P 7) ○ GN₂ / He PRESSURE SYSTEM
- P 8) ○ GIMBALED ENGINES
- P 9) ○ EXTENSIVE RECOVERY &
REFURBISHMENT

NOTE:

These items were consistent
with the preliminary ALS RFP
but may not be applicable to
current design concepts

No: P 1

Operations Requirement:

Simplified, integrated, robust propulsion system that, using the same oxidizer and fuel, provides the essential elements of:

main propulsion

orbit insertion

attitude/rendezvous control

Rationale:

Current propulsion systems started with an engine design and then the MPS built around it.

There is a necessity to simplify and integrate all propulsion systems in order to radically minimize the supporting operations and maintenance.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: P 1.1

Operations Requirement:

Design and develop main propulsion system rocket engines that are fully throttleable from near 0 to 100%. For upper stages, this is an alternate to a straight pressure-fed engine but has higher related operations cost, since it doesn't eliminate turbopumps.

Rationale:

The SSMEs can be throttled from 65% to over 100% only. With multiple restart and lower thrust capability, the MPS could be used for orbital maneuvering (OMS); thereby saving cost, weight, and T&C/O of separate OMS systems.

FOR: Sample Concept:
Technology Requirements:
Technology References: } See FINAL REPORT, Vol. 4

S G O E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SLSOC

Soft Engine Start

PRESNTED AT

RSC

APR. 6, 1988

No: P 1.2

Operations Requirement:

Revise rocket engine start transient time specifications to allow significantly slower start time.

Rationale:

Existing SSME rapid start can reduce life expectancy and increase refurbishment frequency of turbopump bearings, seals, and propellant valves.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: P 1.3

Operations Requirement:

Provide TVC or some form of vehicle attitude control during MPS operation if gimballed engines are eliminated.

Rationale:

Simplifying the vehicle systems and ground operations by deleting gimballed engines and associated systems requires alternate method of TVC or vehicle attitude control during MPS operation as proposed in Item P1.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: P 1.4

Operations Requirement:

Simplify propellant procurement, transport, storage, pumping, safety equipment and procedures by designing vehicles using only one oxidizer and one fuel.

Rationale:

Each individual propellant ground system requires its own little army of engineers, technicians, safety, and expensive, hazardous facilities / GSE.

STS has five propellant components, each of which require separate storage, pumping , GSE, safety, operational procurement, transport, technicians, etc. procedures, engineers,

FOR: Sample Concept:
Technology Requirements:
Technology References:
} See FINAL REPORT, Vol. 4

No: P 2

Operations Requirement:

Delete OMS and RCS as separate systems from MPS.

Rationale:

If MPS can be utilized for OMS and RCS, it may significantly lighten vehicle and will simplify ground support operations.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

Eliminate High-Maintenance Turbopumps

No: P 3

Operations Requirement:

The ideal requirement is to eliminate high maintenance turbopumps.
The turbopumps must be made more robust to reduce refurbishment/maintenance requirements for recoverable stages.

Rationale:

Turbopumps are costly to develop and manufacture, heavy, run at very high RPM, and are cavitation-sensitive devices.

Rocket engine cost, refurbishment frequency, refurbishment cost, and T&C/O time consumption are largely driven by turbopump sensitivity.

Pressure-fed engines with plug nozzles are a viable prospect as specific impulse is relatively insensitive to chamber pressure per se.

FOR: Sample Concept:
Technology Requirements:
Technology References: } See FINAL REPORT, Vol. 4

No: P 4

Operations Requirement:

Provide high thrust actuators for vehicle systems using a system other than hydraulic.

Rationale:

Hydraulic systems are heavy, complex, and plagued with O&M and GSE activities. Vehicle and ground support operations would be greatly simplified if a simpler, more reliable alternative is developed.

FOR: Sample Concept:
Technology Requirement:
Technology References: } See FINAL REPORT, Vol. 4

No: P 5

Operations Requirement:

No use of hyergols for launch, orbital propulsion, or APU systems.

Rationale:

A very significant quantity of non-productive manhours occurs during each flow for "area clear" required during hazardous "opening", entry, or operation of OMS and RCS orbiter systems. There is also a snowballing effect in facilities and O&M requirements for special ventilation, scrubbers and a multitude of safety equipment, including a small army specially trained to do their job in SCAPE (self-contained atmospheric protective ensemble) suits. Further, a pound of hyergol costs about \$8.00, whereas, a LOX/H₂/H₂ mix costs less than \$0.22/lb; a LOX/CH₄ mix costs less than \$0.15/lb; and a LOX/C₃H₈ costs less than \$0.08/lb.

Further, the use of hyergols (and solid propellants also) at the launch rates and large quantities envisioned presents a very severe environmental hazard.

FOR: Sample Concept:
Technology Requirement:
Technology References:

See FINAL REPORT, Vol. 4

SLSOC

No GN2/He On-board Purges

S G O E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

No: P 6

Operations Requirement:
Delete launch vehicle on-board GN2 and He purge systems.

Rationale:
Subject systems add weight to vehicle and electro / mechanical / pneumatics require special small O&M army and much time for ground processing and launch.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

SLSOC
No GN2/He Pressure Systems

No: P 7

Operations Requirement:

Delete GN2 and He valves control plumbing and propellant tankage pressure systems.

Rationale:

Elimination of GN2 and He storage bottles, supply valves, manifolds, plumbing, and multiple test and checkout, will significantly lighten the vehicle, and simplify and speed-up ground support operations.

FOR: Sample Concept:
Technology Requirement:
Technology References:

See FINAL REPORT, Vol. 4

No: P 8

Operations Requirement:

Devise thrust vector or vehicle attitude control system which eliminates, need for gimbaled engines and associated hydraulics, seals, pivots, bellows, etc.

Rationale:

Gimbal systems are expensive and heavy, and add a severe burden of O&M, and test and checkout to ground support operations.

FOR: Sample Concept:
Technology Requirement:
Technology References: } See FINAL REPORT, Vol. 4

SGO ET STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES STUDY
PHASE - 2 FINAL PRESENTATION

PRESENTED AT
KSC
APR. 6, 1988

INTRODUCTION
OPERATIONAL ANALYSES
MANAGEMENT & SYSTEM ENGINEERING
AVIONICS & SOFTWARE
POWER
STRUCTURES & MATERIALS
PROPELLION
FACILITIES & SUPPORT EQUIPMENT
CONCLUSIONS & PRODUCT SUMMARY
PHASE 3

SIMPLIFIED LAUNCH SYSTEM OPERATIONAL CRITERIA
FACILITIES & SUPPORT EQUIPMENT

PRESENTED AT
KSC
APR. 6, 1988

L 1) ● 100% COMPUTER CONNECTIVITY

● AUTOMATION

- L 2) ● ELECTRONIC OMIs

- L 3) ● TEXT AND GRAPHICAL DATA ACQUISITION

- L 4) ● TEST REQUIREMENT VERIFICATION

● STAGE ASSEMBLY

- L 5) ● INITIAL NEAR LAUNCH CENTER

- L 5) ● FINAL AT LAUNCH CENTER

□ L 6) ● HORIZONTAL PROCESSING

- L 7) ● HORIZONTAL TRANSPORT

● PAYLOADS

- L 10) ● ONE AUTONOMOUS CONTAINER

● PAD

- L 8) ● BARREN PAD
- L 9) ● ERECT/MATE STAGES AT PAD
- L 8.1) ● DEEP WATER EXHAUST BUFFER
- L 8) ● LIGHTNING / LIGHTING TOWER
- L 8.2) ● FLY-AWAY CONNECTS ONLY
- L 8) ● PROPELLANT FARM
- L 6) ● PAVED TOW - WAY
- MOBILE EQUIPMENT
- L 6) ● STANDARD AIRCRAFT TUG
- L 6) ● STRAP-ON WHEELED DOLLIES
- L 6) ● MOBILE CRANE
- BUILDINGS
- L 6) ● HORIZONTAL PROCESSING FACILITY

ELIMINATE

- PAD EQUIPMENT
 - L 4) ○ HARDWIRE CONNECTS
 - L 8.4) ○ ACCESS STRUCTURES
 - L 8.3) ○ SWINGARMS
 - L 8) ○ RETRACTING UMBILICALS
 - L 8.5) ○ T-O HOLD-DOWN
 - L 8.6) ○ DELUGE WATER
 - L 8.6) ○ SOUND SUPPRESSION WATER
 - L 8.1) ○ FLAME TRENCH / DEFLECTOR
 - L 8.7) ○ ECS
 - P 6) ○ He / GN₂ STORAGE
 - E) ○ GROUND POWER
 - L 7) ○ CRAWLER WAY
- MOBILE EQUIPMENT
 - L 7) ○ CRAWLER / TRANSPORTER
 - L 7) ○ MOBILE LAUNCH PLATFORM
 - BUILDINGS
 - L 6) ○ VAB
 - L 6) ○ VPF
 - L 6) ○ RPSF

No: L 1

Operations Requirement:

All computers associated in any manner with operations, flight, or ground must provide and maintain complete connecting (bridging).

Rationale

The vast amount of data required to support and maintain any operational system requires that the maximum efficiency in operations be always maintained. Paperwork currently requires a large portion of the allocated operations budget. A potential reduction of 5% of the total LCC can be achieved by automation of paperwork. Isolated databases must be eliminated to accomplish this.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: L 2

Operations Requirement

Operational and support procedures should be computer-based and maintained.

Rationale:

Conventional hard copy procedures are difficult and expensive to maintain. The manual update, copy and distribution of procedures does not provide for cost effective operations. The lack of procedural discipline results in many errors. Automated procedures would control approvals, procedural sequence, data recording and associated support data presentation.

FOR: Sample Concept:
Technology Requirements:
Technology References:
See FINAL REPORT, Vol. 4

SLSOC
Text and Graphical Data Acquisition

No: L 3

Operations Requirement:

Import and export of text and graphics requires that data formats be standardized. Eliminate hard copy transfer of text and data for information and for approvals.

Rationale:

The large volume of operations and support data is currently generated, maintained, and distributed in hard copy form and is highly labor intensive.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: L 4

Operations Requirement:

Test requirements verification must be automatically correlated with the completion of the associated procedures.

Rationale:

Current manual method is inefficient, inadequate, and error prone.

FOR Sample Concept:
 Technology Requirement:
 Technology References:
 } See FINAL REPORT, Vol. 4

S G O E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SLSOC

Final Stage Assembly at Launch Site

PRESENTED AT
KSC
APR. 6, 1988

No: L 5

Operations Requirement:

Perform initial stage assembly at manufacturing facility near Launch Center.
Perform all stage assembly, refurbishment and T&C/O in one building at the launch center; including installation of autonomous payload.

Rationale:

Simplifies transportation from manufacturing facilities to Launch Center. Vertical clearance inside a C-5A cargo plane is 13.5 ft. Any larger loads must use the SCM (Space Cargo Modified) C-5A or be transported by barge: a lengthy, hazardous, and expensive alternative. The average C-5A delivery flight costs \$150K.

Simplifies and minimizes assembly and T&C/O facilities.

More efficient use of personnel who can be cross-utilized for assembly and for checkout. Proximity of manufacturing facility to Launch Center further enables cross-utilization.

FOR: Sample Concept:
Technology Requirements:
Technology References:

See FINAL REPORT, Vol. 4

No: L 8

Operational Requirement:

Barren pad with essentially no GSE or supporting structures.

Rationale:

A major contributor to ground operations cost is the complexity of GSE and structures at the pad which require constant maintenance and/or refurbishment and modifications. Each of which require small armies of supporting personnel (engineers, technicians, mechanics, clerks, etc.)

A "barren pad" would have:

- * Simple raised concrete structure
- * Deep water exhaust buffer
- * Lightning/lighting tower
- * Propellant farm
- * Mobile crane (as required)
- * Flyaway propellant connections
- * Wireless (infrared/optical/RF) control & data connections

A "barren pad" would not have:

- * Access structures
- * Swingarms
- * Retracting umbilicals
- * T-0 holddown
- * Firebrick flame trench and deflectors
- * Deluge water system
- * Sound suppression water system
- * Large pad terminal connection room
- * Ground power system and related GSE
- * ECS GSE
- * Vehicle system GSE
- * Hardwire connections to vehicle
- * Office and shop facilities

PRESENTED AT

KSC

APR. 6, 1988

SLSOC

Deep Water Exhaust Buffer

S G O E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

No: L 8.1

Operations Requirement:
Simplify flame trench and deflector to eliminate frequent costly
maintenance.

Rationale:

Replacement of firebrick, major refurbishment at repetitive intervals, and consistently high structural erosion of flame deflectors is costly. These should be greatly reduced or eliminated. This aspect is aggravated by high launch rate, e.g., weekly.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

S G O E/T STUDY PHASE-2 FINAL PRESENTATION by BOEING	Flyaway (No Retracting) Connects Only Umbilical	Carrier Plates)
---	--	--------------------

No: L 8.2

Operations Requirement:
Provide simplified vehicle umbilical disconnect systems.

Rationale:

Contemporary quick-disconnect umbilical carriers are very complex, launch-damage susceptible, and manpower-intensive for test and checkout. Post-launch refurbishment is repetitive, costly, and time consuming.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

SLSOC
No Swingarms

PRESENTED AT
KSC
APR. 6, 1988

No: L 8.3

Operations Requirement:

Simplify or eliminate all swingarms with the related ground support operations, equipment, and structures to dramatically reduce repetitive costs.

Eliminate repetitive tests and checkout at pad and post launch refurbishment.

Rationale:

Contemporary swingarms are expensive, complex, O&M intensive, and launch critical systems.

FOR: Sample Concept:
Technology Requirement:
Technology References: } See FINAL REPORT, Vol. 4

No: L 8.4

Operations Requirement:

No vehicle or payload access structure.**Minimize vehicle resident time at pad.
self-test,
launch.****Limited LRU changeout capability at pad (boattail).****Rationale:**

Current STS requires two weeks or more at the pad for extensive interface systems test and checkout, payload access for O&M, vertical P/L insertion, closeout and all-systems verifications. This time period and tedious process is not acceptable for reduced cost and high launch rate.

FOR: Sample Concept:
Technology Requirements:
Technology References:
See FINAL REPORT, Vol. 4

86

Simplified Holdown/release

No: L 8.5

Operations Requirement:

Greatly simplify vehicle holdown systems at pad.

Rationale:

Holdown system of some kind is mandatory to restrain vehicle in high winds and to stabilize motion during engine start. Existing method is costly, dangerous, time-consuming, and not required for continuously variable thrust.

FOR: Sample Concept:
Technology Requirement:
Technology References: } See FINAL REPORT, Vol. 4

No: L 8.6

Operations Requirement:

Eliminate very extensive facilities, personnel, test and checkout procedures, and costly O&M of pad water systems.

Rationale:

If the vehicle does not possess the STS-style MLP/SRB interface physics, sound suppression water is not mandatory. If there are no tower hydraulics, swingarms or heat sensitive GSE/cabling at the pad, deluge water is not mandatory.

Gross simplification of launch pad facilities and operations is essential to reduce cost-to-orbit by factor of 10.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

No: L 8.7

Operations Requirement:

The barren pad has no complex internal rooms and GSE requiring
STS-style pre-launch inert atmosphere and positive pressurization.
Delete similar systems providing vehicle ECS.

Rationale:

These are costly in O&M personnel and test / checkout / pre-launch
validation time, and are not necessary in the proposed "barren pad".

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

Payloads: Standard Autonomous Cargo Container

No: L 10

Operations Requirement:

Provide only simple mechanical interface between launch vehicle and payload.

Rationale:

Orbiter payload bay modifications and payload flight support equipment software modifications are among the most time consuming ground support operations.

For existing ELV's; each interface requires extensive GSE and T&C/O.

FOR: Sample Concept:
Technology Requirement:
Technology References:
See FINAL REPORT, Vol. 4

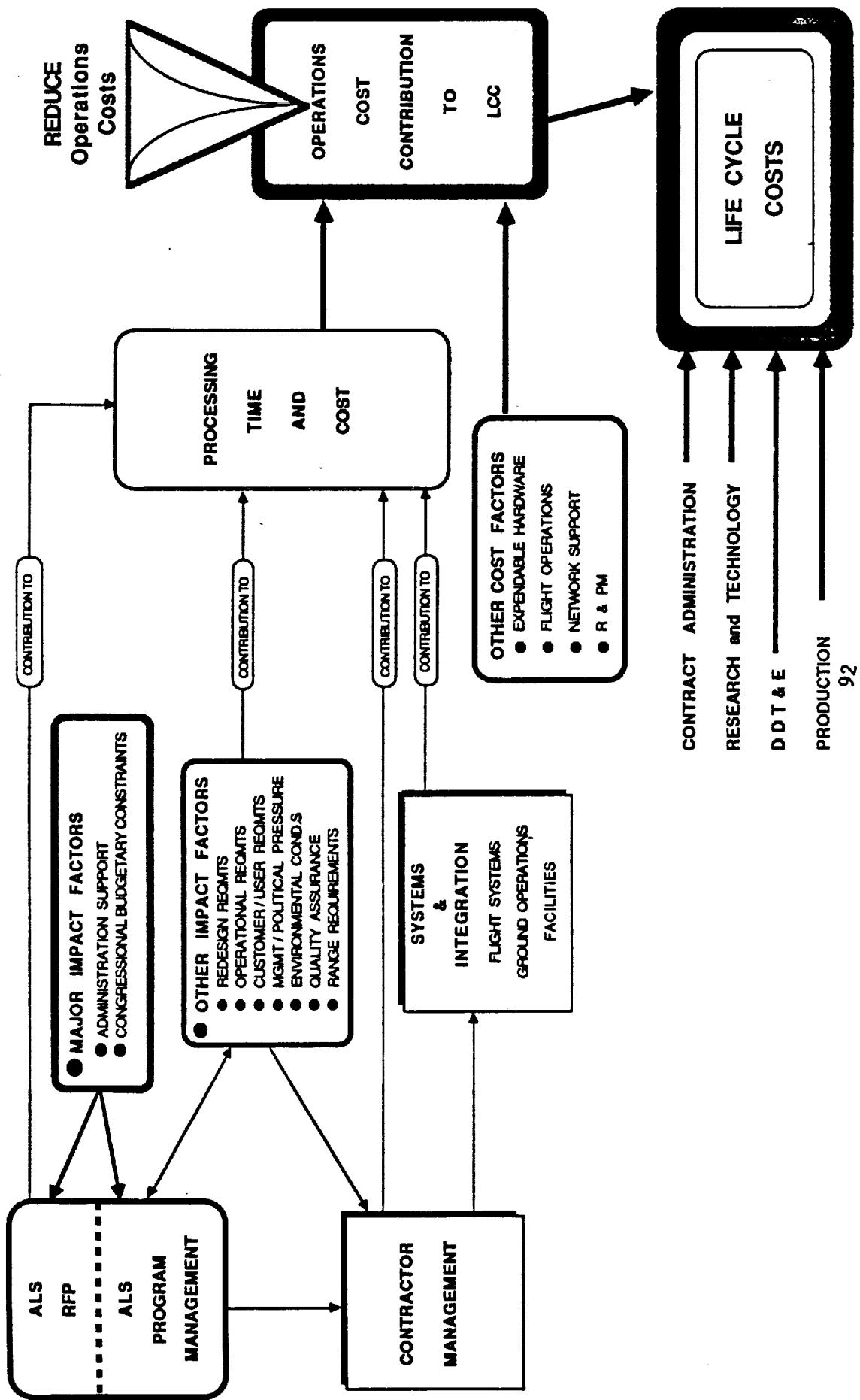
SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES STUDY
PHASE - 2 FINAL PRESENTATION

PRESENTED AT
KSC
APR. 6, 1988

- INTRODUCTION
- OPERATIONAL ANALYSES
- MANAGEMENT & SYSTEM ENGINEERING
- AVIONICS & SOFTWARE
- POWER
- STRUCTURES & MATERIALS
- PROPULSION
- FACILITIES & SUPPORT EQUIPMENT
- CONCLUSIONS & PRODUCT SUMMARY**
- PHASE 3

COST CONTRIBUTORS

PRESENTED AT
KSC
APR. 6, 1988



SG O/E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SIMPLIFIED LAUNCH SYSTEM
OPERATIONAL CRITERIA (SLSOC)

PRESENTED AT
KSC
APR. 6, 1988

MANAGEMENT & SYSTEM
ENGINEERING

- M 1) ● PROCUREMENT
- M 2) ● DESIGN / BUILD TEAMS
- M 3) ● DENIMING STYLE MANAGEMENT
- M 4) ● LIFE CYCLE COSTS
- M 5) ● DESIGN TO COST
- M 6) ● UNIFIED LIFE CYCLE ENGINEERING
- M 7) ● RISK MANAGEMENT
- M 8) ● RELIABILITY / OPERABILITY
- M 9) ● MAINTAINABILITY / SUPPORTABILITY
- M 10) ● LOGISTICS SUPPORT
- M 11) ● OPERATIONAL TEST REQUIREMENTS
- M 12) ● QUALITY ASSURANCE
- M 13) ● SAFETY
- M 14) ● SECURITY
- M 15) ● CONNECTIVITY ARCHITECTURE

ELIMINATE

- M 11) ○ MULTIPLE PRIME CONTRACTORS
ON SAME PROGRAM
- M 6) ○ TIER TEAMS FOR STATUS (SEE 1.1)
(Requires 100% Computer Connectivity)
- M 1) ○ SEPARATE DESIGN CONTRACTORS /
VOLUMINOUS INTERFACE CONTROL
- M 12) ○ LARGE QUALITY INSPECTION TEAMS
- M 10) ○ CANNIBALIZATION
- M 4) ○ COST OVERBUILDS & UNLIMITED LOC
- M 7) ○ EXHIBITANT COST TO ATTEMPT
ZERO RISK REQUIREMENTS

NOTE

- THESE ITEMS WERE CONSISTENT WITH
THE PRELIMINARY ALIS RFP BUT MAY
NOT BE APPLICABLE TO CURRENT
DESIGN CONCEPTS

AVIONICS & SOFTWARE

- E) ● AUTONOMOUS VEHICLE
 - A 1) ○ BIT/BITE ON-BOARD CHECKOUT
 - A 2) ○ FAULT TOLERANT AVIONICS SUITE
 - A 1) ○ VEHICLE HEALTH & STATUS MONITORING SYSTEM
- E) ● PROPELLANT GRADE FUEL CELLS
- E) ● STATE - OF - ART ENERGY SOURCES
 - A 4) ○ MINIMAL LAUNCH CONTROL INTERFACE
 - A 1) ○ RETURNED VEHICLE SELF - TEST FOR REFLEET
 - A 3) ○ AUTONOMOUS G/HAC
 - A 4) ○ OPTICAL/R/F LINK ONLY TO ONE
- E) ● SYSTEM SIZED TO PAR FOR GROUND OPERATIONS
 - A 3) ○ SEPARABLE TPA
 - A 2) ○ ALL ORDNANCE
 - A 3) ○ PROPELLANT SAFETY RESTRICTIONS
- E) ● SOFTWARE
 - A 1) ○ COMMON CORE SOFTWARE FOR G/O, LAUNCH, FLIGHT
 - A 1) ○ OPERATIONS DATA OVERLAYS (G/O, LAUNCH, MISSION)
- E) ● ELIMINATE
 - A 1) ○ RELATED G/HAC
 - A 1) ○ HARDWARE CONNECTS TO ONE
 - A 1) ○ GROUND POWER REQUIREMENTS

STRUCTURES & MATERIALS

- E) ● LOW MAINTENANCE ENERGY STORAGE
 - S 1) ○ MINIMIZE LEAK PATHS
 - S 2) ○ STRUCTURAL INTEGRITY VERIFICATION
 - S 3) ○ INTEGRAL TPS
 - S 4) ○ CANNON
- E) ● STATE - OF - ART ENERGY SOURCES
 - S 1) ○ WEAPON DESTROY
 - S 2) ○ LASER IGNITION
 - S 3) ○ ACCELERATION (CLIMB)
 - S 4) ○ NITRO/L-E - M DEVICES
- E) ● ELIMINATE
 - S 2) ○ SEPARATE OAS AND PAR
 - S 2) ○ HIGH MAINTENANCE TURBOLEAPS
 - S 2) ○ HYDROULICS
 - S 2) ○ ON-BOARD PURGE SYSTEM
 - S 2) ○ IN PRESSURE SYSTEM
 - S 2) ○ CANISTERED ENGINES
 - S 2) ○ EXTENSIVE RECOVERY & REFURBISHMENT
- E) ● PROVIDE ON-SO PAR FOR GROUND OPERATIONS
 - S 3) ○ ALL ORDNANCE
 - S 3) ○ PROPELLANT SAFETY RESTRICTIONS
- E) ● ELIMINATE
 - A 1) ○ RELATED G/HAC
 - E 1) ○ GROUND POWER REQUIREMENTS

PROPELLANT

- E) ● IMPROVED STRUCTURE SYSTEM
 - L 1) ○ 100% COMPUTER CONNECTIVITY
 - L 1) ○ AUTOMATION
 - L 2) ○ ELECTRONIC OMS
 - L 3) ○ TEST AND GRAPHICAL DATA ACQUISITION
 - L 4) ○ TEST REQUIREMENT VERIFICATION
 - L 5) ○ STAGE ASSEMBLY
 - L 6) ○ INITIAL NEAR LAUNCH CENTER
 - L 7) ○ FINAL AT LAUNCH CENTER
- E) ● AMPLIFIED ROBUST PROPULSION SYSTEM
 - P 1) ○ AMPLIFIED ROBUST PROPULSION SYSTEM
 - P 1.1) ○ FULLY THROTTLEABLE ENGINES (MULTI-PHASE)
 - P 1.2) ○ SOFT ENGINE START
 - P 1.3) ○ TIC BY DELTA THRUST AND OR NOZ/ABR
 - P 1.4) ○ ONE OXODIZE/ONE FUEL
- E) ● ELIMINATE
 - P 2) ○ PAYLOADS
 - P 2) ○ PAYLOADS
- E) ● HORIZONTAL PROCESSING
 - L 6) ○ HORIZONTAL TRANSPORT
 - L 6) ○ HORIZONTAL TRANSPORT
- E) ● BUILDINGS
 - L 6) ○ BUILDINGS
- E) ● HORIZONTAL PROCESSING FACILITY

FACILITIES & SUPPORT EQUIPMENT

- L 1) ○ 100% COMPUTER CONNECTIVITY
- L 1) ○ AUTOMATION
- L 2) ○ ELECTRONIC OMS
- L 3) ○ TEST AND GRAPHICAL DATA ACQUISITION
- L 4) ○ TEST REQUIREMENT VERIFICATION
- L 5) ○ STAGE ASSEMBLY
- L 6) ○ INITIAL NEAR LAUNCH CENTER
- L 7) ○ FINAL AT LAUNCH CENTER
- L 8) ○ BARREN PAD
- L 8) ○ EJECT/WATE STAGING AT PAD
- L 8) ○ DEEP WATER EXHAUST BUFFER
- L 8) ○ LIGHTNING/LIGHTING TOWER
- L 8) ○ RAILWAY CONNECTS ONLY
- L 8) ○ PROPELLANT FARM
- L 8) ○ PAVED TOW-WAY
- L 8) ○ MOBILE EQUIPMENT
- L 8) ○ STRAIGHT WHEELED DOLIES
- L 8) ○ MOBILE CRANE
- L 8) ○ BUILDINGS
- L 8) ○ HORIZONTAL PROCESSING FACILITY

ELIMINATE

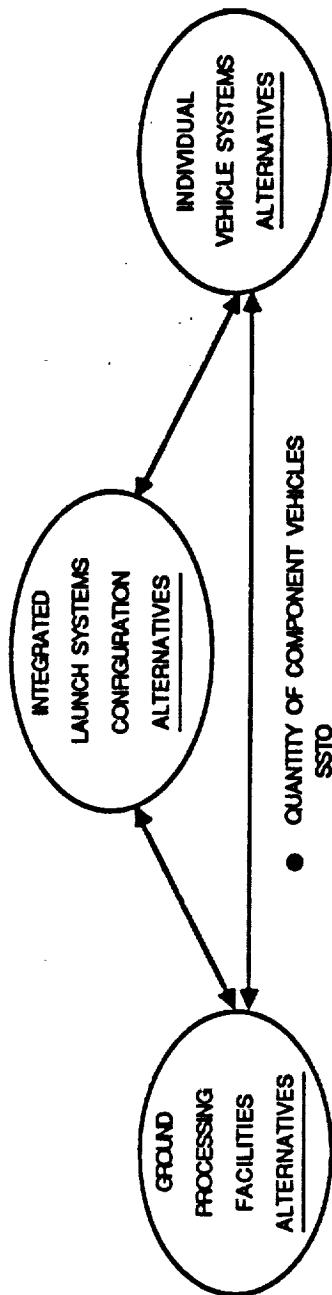
- O) AUTOMATION
 - L 11) ○ ISOLATED DATABASES
 - L 12) ○ PAPERWORK RELATED TO TEST REQUIREMENTS
 - L 13) ○ SECURED TRANSFER OF TEXT/DATA
 - L 14) ○ PRINTED TRANSFER OF TEXT/DATA
 - L 15) ○ TO HOLD-DOWN DELEGE MATER
 - L 16) ○ SOUND SUPPRESSION WATER
 - L 17) ○ RUMBLE TROUGH/DEFLECTOR
 - L 18) ○ HE/GN * STORAGE
 - E 1) ○ GROUND POWER CRAWLER WAY
 - E 1) ○ MOBILE EQUIPMENT
 - E 1) ○ CRAWLER TRANSPORTER
 - E 1) ○ MOBILE LAUNCH PLATFORM
 - O) BUILDINGS
 - L 6) ○ WAB
 - L 6) ○ WFF
 - L 6) ○ RFSF
- O) PAYLOAD / VEHICLE INTEGRATION
 - L 10) ○ LIFTING VEHICLES: CLEAR OF GROUND
- O) VERIFICATION TESTING
- O) LIFTING VEHICLES: CLEAR OF GROUND

ELIMINATE

- M 11) ○ MULTIPLE PRIME CONTRACTORS ON SAME PROGRAM
- M 6) ○ TIER TEAMS FOR STATUS (SEE 1.1)
(Requires 100% Computer Connectivity)
- M 1) ○ SEPARATE DESIGN CONTRACTORS / VOLUMINOUS INTERFACE CONTROL
- M 12) ○ LARGE QUALITY INSPECTION TEAMS
- M 10) ○ CANNIBALIZATION
- M 4) ○ COST OVERBUILDS & UNLIMITED LOC
- M 7) ○ EXHIBITANT COST TO ATTEMPT ZERO RISK REQUIREMENTS

**SLSOC STUDY
(VERTICAL LAUNCH ASSUMED)**

PRESENTED AT
KSC
APR. 6, 1988



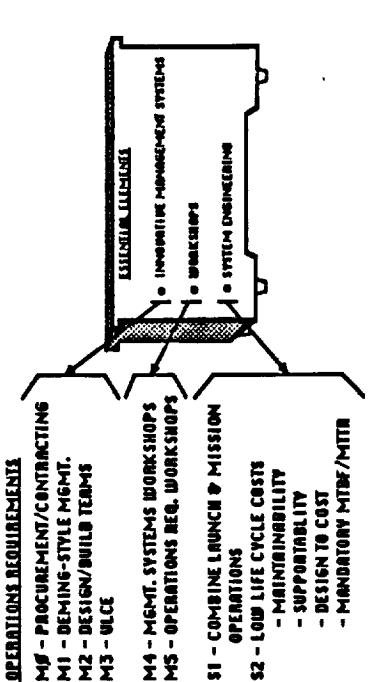
- VEHICLE PROCESSING MODE
 - VERTICAL HORIZONTAL COMBINATION
 - PAYLOAD PROCESSING MODE
 - VERTICAL HORIZONTAL COMBINATION
 - PAYLOAD INTEGRATION
 - OFF ONLY VAB ONLY PAD ONLY COMBINATION
 - VEHICLE MATE HORIZONTAL VERTICAL
 - ERECTION VAB PAD
 - VEHICLE ACCESS ALL LOCATIONS
- SSTO
 - 2 - STAGE STACK PARALLEL COMBINATION
 - FUEL
 - SINGLE MULTIPLE RECOVERABLE
 - ALL PART NONE
 - COMPONENT VEHICLE MATING
- QUANTITY OF COMPONENT VEHICLES
 - 3 - STAGE
 - LANDING
 - HORIZONTAL VERTICAL LAND WATER
 - MANNED
 - FLIGHT CREW PASSENGER MODULE ONLY
- INDIVIDUAL VEHICLE SYSTEMS ALTERNATIVES
 - PROPELLANTS
 - RP-1 LH₂ CH₄ C₃H₈ SOLIDS HYPERGELS
 - ON - BOARD POWER
 - FUEL CELLS BATTERIES COMBINATIONS HYDRAULIC SUPPLY APU MPS
 - PNEUMATICS
 - PURGE VALVE CONTROL
 - TEST - & C / O
 - MANUAL AUTOMATIC INTEGRATED PRESSURIZATION BOTTLES AUTOGENOUS MPS

THE UNAVOIDABLE INTERRELATIONSHIPS OF GROSS VEHICLE CONFIGURATION, VEHICLE SYSTEMS, AND GROUND SUPPORT PROCESSING ARE INDICATED. PRELIMINARY DESIGN MUST ACCOMMODATE EXPERIENCED PERSONNEL FROM ALL THREE TO MINIMIZE LCC

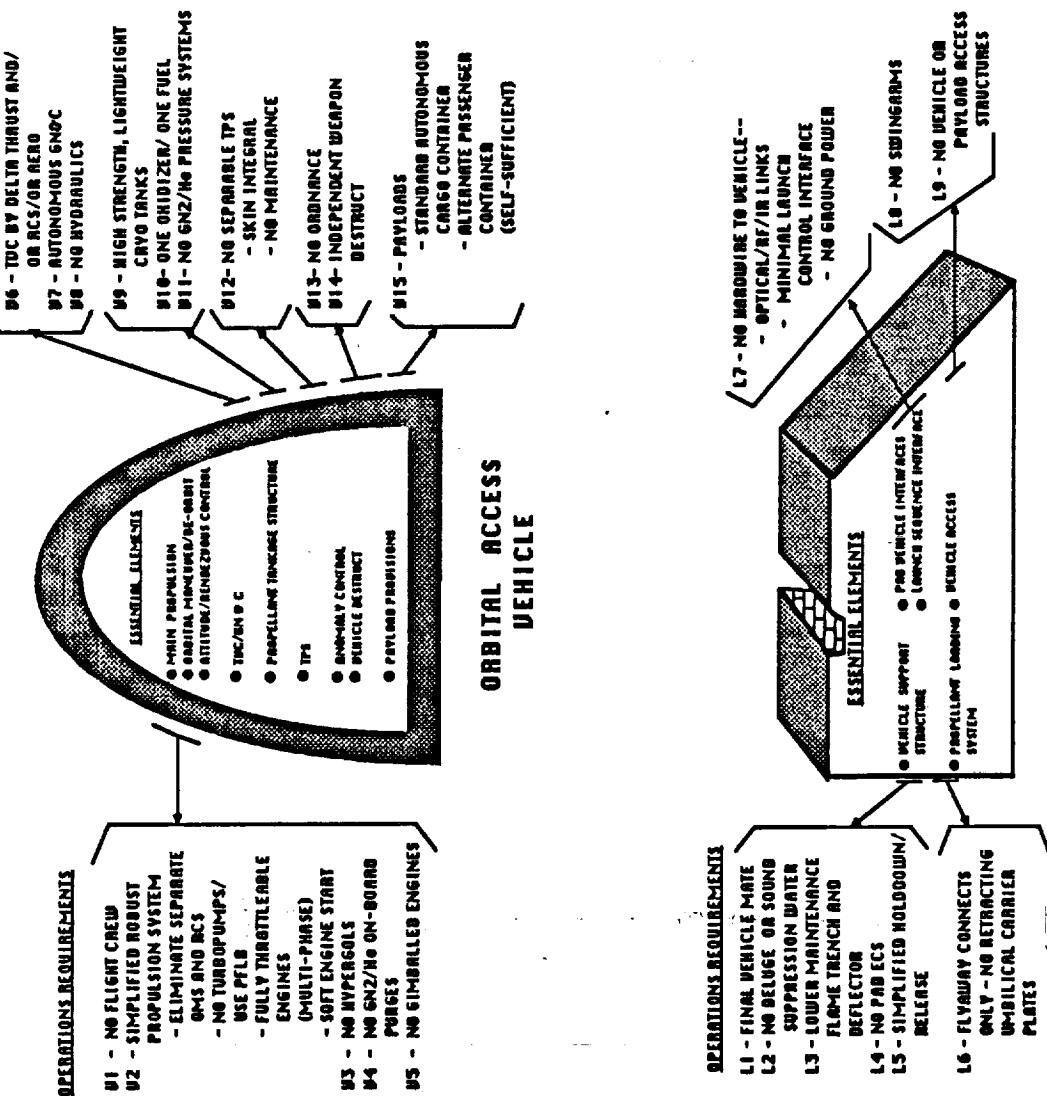
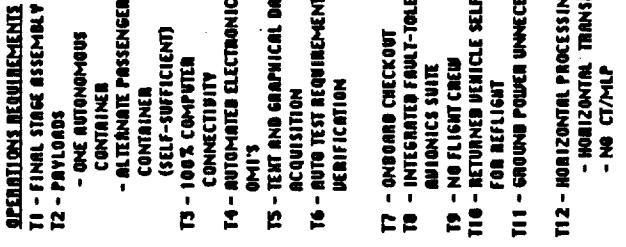
**SGO ET STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING**

CIRCA 2000 SYSTEM

**PRESENTED AT
KSC
APR. 6, 1988**



**MANAGEMENT & SYSTEM
ENGINEERING**



MANAGEMENT & SYSTEM ENGINEERING

THE TECHNOLOGIES REQUIRED IN THIS AREA ARE AVAILABLE AND WILL SUPPORT IF THEIR USE IS MANDATED BY UPPER MANAGEMENT. THERE ARE SEVERAL MANAGEMENT METHODS AVAILABLE THAT WILL PROVIDE SOLUTIONS FOR THESE PROBLEMS. MUCH OF THE SUPPORTING TECHNOLOGIES ARE ESTABLISHED AND READILY AVAILABLE.

ENABLING METHODOLOGIES / STATUS;

DESIGN BUILD TEAMS / COMMERCIALLY AVAILABLE
DEMING-STYLE MANAGEMENT / COMMERCIALLY AVAILABLE
RISK MANAGEMENT / COMMERCIALY AVAILABLE

RELATED SUPPORTING TECHNOLOGIES / STATUS;
ULCE / SECTIONS ARE COMMERCIALY AVAILABLE -- REMAINDER / STATE - OF - THE - ART
COMPUTER CONNECTIVITY / AVAILABLE

AVIONICS & SOFTWARE

THE TECHNOLOGIES REQUIRED FOR SOLUTION OF THESE PROBLEMS ARE WELL ESTABLISHED AND ARE IN CURRENT USE BY THE MAJORITY OF THE AIRLINE AND ELECTRONICS MANUFACTURERS.

ENABLING TECHNOLOGIES / STATUS;

VHMS (WITH BIT & BITE) / COMMERCIALY AVAILABLE
IFTAS / STATE - OF - THE - ART
RF & INFRARED CONTROL / COMMERCIALY AVAILABLE
DISTRIBUTED ARCHITECTURES / COMMERCIALY AVAILABLE

SLSOC TECHNOLOGY REQUIREMENTS
STATUS / SUMMARY
(Cont'd)

PRESNTED AT
KSC
APR. 6, 1988

POWER

THE SOLUTIONS ARE IN WORK FOR IMPROVED ON - BOARD POWER SUFFICIENT TO SUPPORT ALL GROUND OPERATIONS TESTING AND FLIGHT OPERATIONS, THEY ARE NOT YET AVAILABLE. TO MEET THE REQUIREMENTS FOR THE NEXT GENERATION OF VEHICLE WILL REQUIRE ACCELERATED DEVELOPMENT OF HIGH - CAPACITY / HIGH - DENSITY ENERGY STORAGE SYSTEMS WITH EMPHASIS ON FUEL CELLS AND CONSIDERATION OF ADVANCED BATTERIES SUCH AS SODIUM / SULPHUR.

ENABLING TECHNOLOGIES / STATUS;

ADVANCED FUEL CELLS / IN DEVELOPMENT BUT BEYOND CURRENT STATE - OF - THE - ART
SODIUM-SULPHUR BATTERIES / IN DEVELOPMENT BUT BEYOND CURRENT STATE - OF - THE - ART

STRUCTURES & MATERIALS

THE AEROSPACE INDUSTRY AS A WHOLE IS RAPIDLY DEVELOPING THE APPLICATIONS TO SOLVE MANY OF THE PROBLEMS ASSOCIATED WITH STRUCTURES & MATERIALS AND PROVIDING FOR IMPROVEMENTS IN THE STRUCTURAL VERIFICATION OF RECOVERABLE VEHICLES, ELIMINATION OF ORDNANCE, AND ELIMINATION OF POTENTIAL FUEL / OXIDIZER LEAK PATHS.

ENABLING TECHNOLOGIES / STATUS;

STRAIN AND CORROSION SENSING INSTRUMENTS / COMMERCIALLY AVAILABLE
LASER IGNITION SOURCES / COMMERCIALY AVAILABLE
MOTION GENERATION MATERIALS (NITINOL) / COMMERCIALY AVAILABLE
LEAKPROOF FITTINGS (NITINOL COLLARS) / COMMERCIALY AVAILABLE
INDEPENDENT WEAPON DESTRUCT / STATE - OF - THE - ART

NO FACING PAGE TEXT

PROPELLION

THE TECHNOLOGY OF ROCKET ENGINES HAS BEEN DEVELOPING MORE COMPLEX COMBUSTION CYCLES, MORE ROTATIONAL SPEEDS, HIGHER PRESSURES, HIGHER TEMPERATURES AND IN GENERAL SEEM TO BE LEADING TOWARD HIGHER COSTS AND EVEN MORE DIFFICULT O & M. THE TECHNOLOGY TO DEVELOP SIMPLER, AND CHEAPER ENGINES EXISTS.

ENABLING TECHNOLOGY / STATUS;

SOFT START / COMMERCIALLY AVAILABLE (RL-10)
FULLY THROTTLEABLE / COMMERCIALLY AVAILABLE (RL-10)
ELIMINATION OF HIGH MAINTENANCE TURBOPUMPS / STATE - OF - THE - ART
MULTI-PHASE ENGINES / BEYOND STATE - OF - THE - ART

FACILITIES & SUPPORT EQUIPMENT

THE QUANTITY, COMPLEXITY AND OPERATIONAL MANPOWER REQUIREMENTS FOR GROUND SUPPORT FACILITIES ARE DRIVEN ENTIRELY BY BASIC VEHICLE CONFIGURATION. THE LARGEST ITEM NOT DIRECTLY AFFECTED BY THE VEHICLE CONFIGURATION IS THE PAPER WORK ASSOCIATED WITH GROUND OPERATIONS. THE TECHNOLOGY ASSOCIATED WITH THE REDUCTION / ELIMINATION OF PAPER WORK IS READILY AVAILABLE

ENABLING TECHNOLOGY / STATUS;

COMPUTER CONNECTIVITY / COMMERCIALLY AVAILABLE
ELECTRONIC PROCEDURES / COMMERCIALLY AVAILABLE
TEXT AND GRAPHICAL DATA ACQUISITION / STATE-OF-THE-ART
AUTOMATED REQUIREMENTS VERIFICATION / STATE-OF-THE-ART

SIMPLIFIED LAUNCH SYSTEM
OPERATIONAL CRITERIA (SLSOC)
CONCLUSIONS

PRESNTED AT
KSC
APR. 6, 1988

- SIMPLIFIED, EXPENDABLE, UNMANNED VEHICLES OF CONVENTIONAL TECHNOLOGY,
DO NOT SHOW PROMISE OF MEETING \$300 / LB LEO ALS GOAL EVEN WITH HIGHLY
SIMPLIFIED GROUND OPERATIONS; \$750 IN FY -86 \$ IS MORE LIKELY.
- EXPENDABLE BOOSTER COST CAN EQUAL A SIGNIFICANT PORTION OF TOTAL
EXPENDABLE FLIGHT HARDWARE COST. AN EASILY MAINTAINED REUSABLE
BOOSTER PROVIDES A WAY TO REDUCE COSTS AND APPROACH THE ALS GOAL
- ADDITION OF A P/A MODULE TO AN EXPENDABLE CORE STAGE OR USE OF A
SERIES OF RECOVERABLE ENGINE PODS MAY REDUCE LIFE CYCLE COSTS BUT MAY
REQUIRE ADDITIONAL LAUNCH SITE FACILITIES AND GROUND SUPPORT
OPERATIONS.
- THE BULK OF THE WORK ELEMENTS PORTRAYED IN THIS PRESENTATION REQUIRE
THE USE OF COMMERCIALLY AVAILABLE TECHNOLOGIES WITH NO RISK -- OR
STATE-OF-THE-ART TECHNOLOGIES THAT CAN BE USED WITH VERY LITTLE RISK.

CIRCA 2000 SYSTEM
CONCLUSIONS

PRESENTED AT

KSC

APR. 6, 1988

- FOR A ROBUST, REUSABLE VEHICLE (BOOSTER AND ORBITER), REDUCTION IN FLIGHT SYSTEMS QUANTITIES AND COMPLEXITIES (WITH ATTENDANT REDUCTION IN GSO AND FACILITIES) PRODUCES EXPONENTIAL LCC REDUCTION.
- CARGO COSTS OF \$600 / LB TO LEO (FY - 85 \$) APPEARS POSSIBLE WITH A LAUNCH RATE OF 24 / YR. THIS COST IS 11 PERCENT OF STS.

COST DRIVER MINDSETS
(REQUIRED CHANGE)

- PROJECT (OR ACCEPT) LOW FRONT-END PROGRAM COSTS TO SELL PROGRAM.
(REQUIRE LIFE CYCLE COST DATA BE PRESENTED IN INITIAL PROPOSALS)
- "NOT MY PROBLEM"
(DESIGN - BUILD TEAMS)
- "FIRST THINGS FIRST"
(DESIGN - BUILD TEAMS / ULCE / MULTI- YEAR FUNDING)
- REQUIREMENT FOR ARMY OF QUALITY INSPECTORS
(DEMMING TYPE MANAGEMENT)
- COST TRADES DONE AT LOWEST HARDWARE LEVELS (i.e., circuits)
(COST TRADE JUSTIFICATION AT CONCEPT LEVEL)
- MAXIMUM ENGINE SPECIFIC IMPULSE
(ROBUST ENGINES)

COST DRIVER MINDSETS
(REQUIRED CHANGE)
(Cont'd)

- RANGE SAFETY REQUIREMENTS AND HARDWARE ARE NOT NEGOTIABLE
- (SUBSTITUTES FOR VEHICLE ORDNANCE)
- CANNIBALIZATION IS AN ACCEPTABLE SUBSTITUTE FOR ADEQUATE SPARES FUNDING
(ADEQUATE SPARES PROVISIONING FROM BEGINNING)
- EXTENSIVE READINESS REVIEW MEETINGS REQUIRED TO APPROVE PROCEEDING WITH OPERATIONS
(AUTOMATED PROCESSING & CONTROL SYSTEM PROVIDES READINESS STATUS AT ALL TIMES)
- ELIMINATES "REVIEW MEETINGS" AND PUTS WORK CONTROL ON THE FLOOR WHERE IT BELONGS.
- RESTRICTIVE LAUNCH SITE LABOR AGREEMENTS ARE INEVITABLE
(NEGOTIATE STRONG CROSS-UTILIZATION AGREEMENTS)
(STANDARDIZE WORK TIME / BREAK AND PAID HOLIDAYS)
- ABSOLUTE SAFETY REGARDLESS OF COSTS
(COST EFFECTIVE RISK MANAGEMENT THRU ADEQUATE REDUNDANCY, ROBUSTNESS, COMPREHENSIVE
VEHICLE HEALTH MONITORING)

PRODUCT SUMMARY

PRESENTED AT

KSC

APR. 6, 1988

PHASE 2 OBJECTIVE	PRODUCT
<p>Identify operations cost drivers for generic space vehicle operations.</p>	<p>Phase 2 Final Report, Vol.3, "Space-Vehicle Operational Cost-Driver Handbook (SOCH)"</p> <p>Contains 27 mgmt, 11 syst engr, 8 technology, and 19 design topics - with a total of 793 checklist items.</p>

PRODUCT SUMMARY
(Cont'd)

PRESENTED AT
KSC
APR. 6, 1988

PHASE 2 OBJECTIVE	PRODUCT
Determine generic operational requirements for ALS including both expendable and recoverable boosters with goal of lb of approximately \$300/lb LEO.	Phase 2 Final Report, Vol. 4, "Simplified Launch System Operational Criteria (SLSOC)" Describes criteria ideal operations requirements; rationale; sample concepts; technology requirements; identifies related reference material; manpower and processing times.
Provide detailed abstracts of technology references to minimize reader research.	Phase 2 Final Report, Vol.5, "Technology References", provides over 300 citation/abstracts from NASA/RECON and DIALOG that are referenced in Volumes 3,4, & 6.

FINAL REPORT

PRESENTED AT
KSC
APR. 6, 1988

VOLUME	TITLE	PAGES
1	EXECUTIVE SUMMARY	30
2	FINAL PRESENTATION MATERIAL	120
3	SOCH (SPACE OPERATIONS COST - DRIVER HANDBOOK) PART 1 COST DRIVERS CHECKLISTS	100
	PART 2 SOCH REFERENCE INFORMATION	200
4	WORKING DRAFT OF SLSOC DOCUMENT (ADVANCED LAUNCH SYSTEMS OPERATIONS REQUIREMENTS)	125
5	TECHNOLOGY REFERENCES	220
6	CIRCA 2000 REQUIREMENTS	150

SGO/E/T STUDY
PHASE-2 FINAL
PRESENTATION
by BOEING

SHUTTLE GROUND OPERATIONS
EFFICIENCIES / TECHNOLOGIES STUDY
PHASE - 2 FINAL PRESENTATION

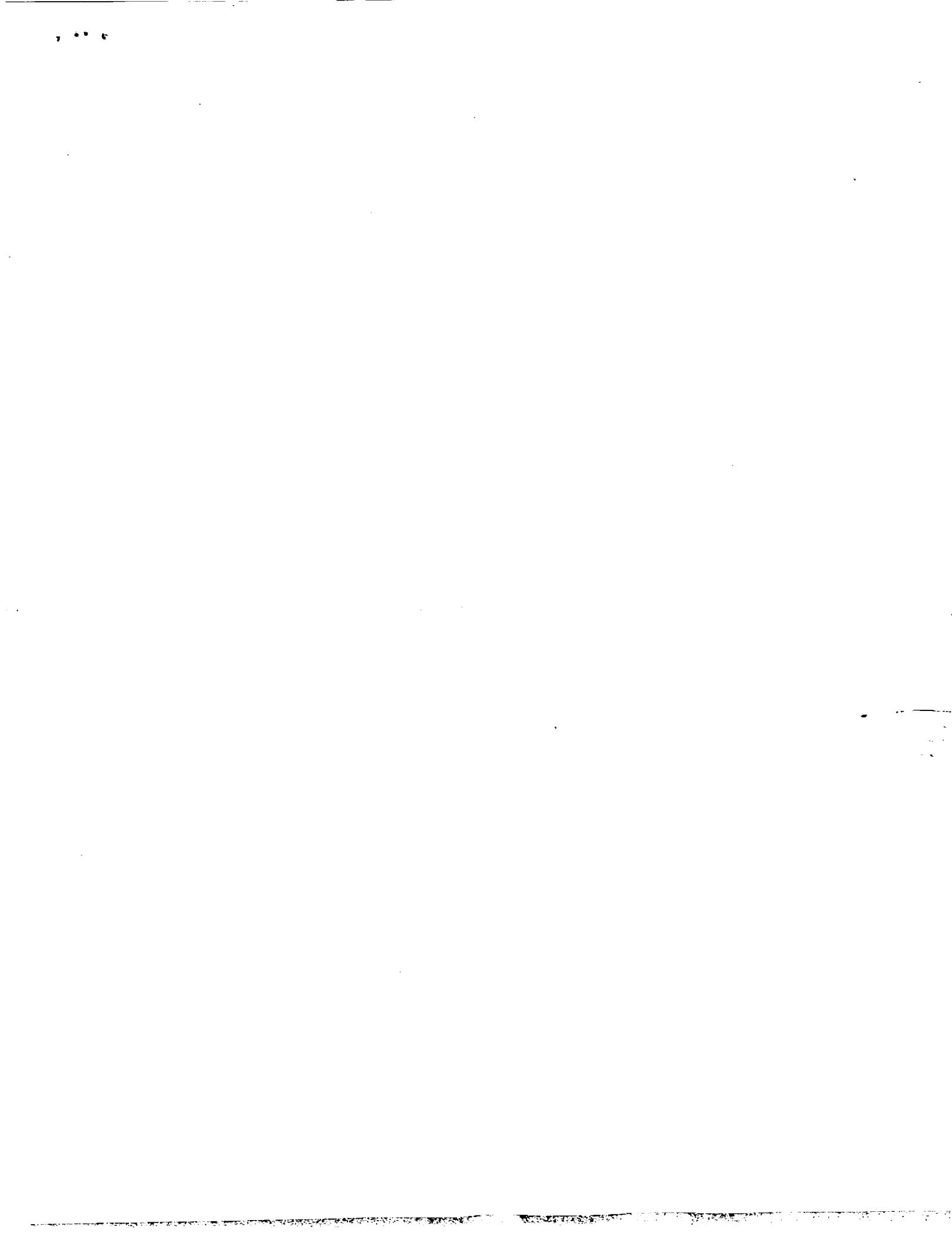
PRESENTED AT
KSC
APR. 6, 1988

- INTRODUCTION
- OPERATIONAL ANALYSES
- MANAGEMENT & SYSTEM ENGINEERING
- AVIONICS & SOFTWARE
- POWER
- STRUCTURES & MATERIALS
- PROPELLION
- FACILITIES & SUPPORT EQUIPMENT
- CONCLUSIONS & PRODUCT SUMMARY

PHASE 3

NO FACING PAGE TEXT

- COMPLETE THE SLSOC DOCUMENTATION
- INITIATE A SERIES OF WORKSHOPS INVOLVING BOTH GOVERNMENT AND DOWN - SELECTED, PRIME CONTRACTOR PERSONNEL TO COLLECTIVELY ADDRESS THE OPERATIONAL PROBLEMS IDENTIFIED IN THE CIRCA 2000 AND SLSOC SYSTEMS APPROACH.
- USE THE WORKSHOPS TO MAKE SURE THE PRIME CONTRACTORS UNDERSTAND THE SIGNIFICANCE OF THE HISTORICAL DATABASE ACCUMULATED -- AND THE BENEFITS OF APPLYING IT TO THEIR TRADE STUDIES.



SHUTTLE GROUND OPERATIONS EFFICIENCIES/TECHNOLOGIES STUDY
DISTRIBUTION LIST

Aerospace Corp.		AMES RESEARCH CENTER	
P. Portanova	MS/558	H. Lum, Dr.	RI 244-7
J. F. Ramon	MS/551	NASA-JSC	
Boeing Aerospace Company		C. Teixeria	ED2
Huntsville	J. B. Winch JA-63	NASA-KSC	
Seattle	V. A. Caluori 8C-59	W. J. Dickinson	PT-FPO (3)
	J. J. Derbes 8A-08	T. A. Feaster	PT-FPO
	D. L. Gregory 8C-59	R. A. Gerron	SF-ENG
	S. I. Gravitz SE-69	T. C. Davis	PT-TPO
	D. W. Hahn 40-57	C. A. Bachstéin	CP-APO
Boeing Aerospace Operations-Fla		E. J. Hecker, Dr.	TM-PCO-2
N. L. Bender	FA-20	J. C. McBrearty	GO-SIO
D. W. Todd	FA-30	G. A. Opresko	SS-LSO
D. L. Morehead	FA-30	E. A. Reynolds	NE
General Dynamics		J. R. Reynolds	RT-SAF
N. Krumm, Dr.	MZ 2635	W. H. Rock	PT
J. J. Morgan	San Diego, CA	G. T. Sasseen	GM
W. C. Strobl	C1-7102	L. L. Schultz	DD-MED-33
M. Waddoups	Ft. Worth, TX	J. M. Spears	PT-TPO
S. B. Seus	MZ 23-8430	D. C. Stout	AC-REQ
J. Washburn	GDSS	R. W. Tilley	SS-OCO
D. Schmidt	GD LC-36	S. L. White	SI-PRO-62
Hughes Aircraft Company		A. N. Wiley	GO-MPO (2)
J. J. O'Connor	Los Angeles, CA	NASA-LaRC	
LSOC		P. Holloway	103A
J. A. Walker	LSO-001	D. Morris	365
G. Oppiger	LSO-013	NASA-LeRC	
H. Lambert	LSO-178	C. A. Auerman	
K. K. Wagy	LSO-178	D. Lanier	PD-34
C. W. Floyd	LSO-178	J. W. Steincamp	PD-34
G. Page	LSO-010	J. Thompson	EA-01
M. W. Edson	LSO-419	C. L. Varnado	PF-20
W. W. Brett	LSO-330	NASA-HQ	
L. L. Yount	LSO-012	D. Branscome	M
G. E. Artley	LSO-389	M. Jacobsen	M
Martin Marietta		J. Cox	SSU
Denver	J. Blackwell G6802	C. Gunn	ML
	B. Zehnle G6802	O. Bumgardner	MO
KSC	C. DiLoreto MMC-30	R. Roberts	SSE
	C. W. Case MMC-G	A. Stofan	S
Michoud	B. Tewell 3001	L. Tilton	MT
RAND Corporation		J. Underwood	D
E. Harris, Dr.	Santa Monica, CA	R. Schneider	B
Rocketdyne		AIR FORCE ASTRONAUTICS	LABORATORY
R. L. McMillion	FA11	L. G. Meyer	CR
McDonnell Douglas Astronautics Co.		G. Haberman	AFRPL/MK/Stop 24
S. J. Obermeyer	Huntington Beach, CA	USAF WRIGHT PATTERSON AFB	
W. Gaubatz, Dr.	Huntington Beach, CA	Lt. Col. J. Coleman	AFHRL/LRA
C. L. Kirkpatrick	St Louis, MO	Maj. M. Link	AFSC/NAX
H. Sams	St Louis, MO	Capt. J. Sponable	AFSC/NAR
E. Sanenger	Huntsville, AL	R. F. Cooper	AFWAL/POJ
K. T. Sory	MDAC-KSC	E. Rachovitsky	AFWAL/FIGL
D. Paul	MDAC-JSC	Col. J. Wormington	SD/CLVH
Rockwell International Corp.		Lt. Col. C. Durocher	SD/CLVH
L. W. Goodman	ZL96	Lt. J. Payne	SD/CLVH
J. Hanley	AD21	T. Cross	SD/CLVH
J. E. Huether	ZL96	C. Eldred	SD/CLVH
R. Gulcher	Lakewood, CA	Capt. G. L. Ourada	SD/XR
E. Brown	Los Angeles, CA	Ms Dana Graves	HqUSAF-LEYYA
L. Moon	Conoga Park, CA	Lt. Col. R. Bowman	HqUSAF-LEYM
Teledyne Brown Engineering		SDIO-Washington, D. C.	
D. DeLong	Huntsville, AL	Col. J. Graham	SDIO/S/ES
USBI Booster Production Company, Inc.		Maj. E. Tavares	SDIO/S/ES
H. P. Blanks	Huntsville, AL	Mr. J. Dryden	SDIO/S/ES
J. H. Beardall	BPC-PI	Lt. Col. T. Shore	SDIO/T/SL
Pratt & Whitney		USAF-VAFB	
C. Sypniewski	West Palm Beach, FL	Capt. V. Villhard	6595 MTG/XR
SAIC		USAF-KSC	
J. Kleperis	Dayton, OH	Lt. Col. T. J. Meeks	GM-AF-2
IDA (Inst. of Def. Analy.)		Capt. G. S. Kirk	SS-LSO-AF
R. G. Fink, Dr.	Washington D.C.	Fluor Daniel Co.	
VITRO		G. Levin	Irvine, CA
W. Revesz, Jr.	VITRO-KSC 4/18/88		